PB-248 104

# ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY, BLACK CREEK PROJECT, ALLEN COUNTY, INDIANA

James Lake, et al

Allen County Soil and Water Conservation District

Prepared for:

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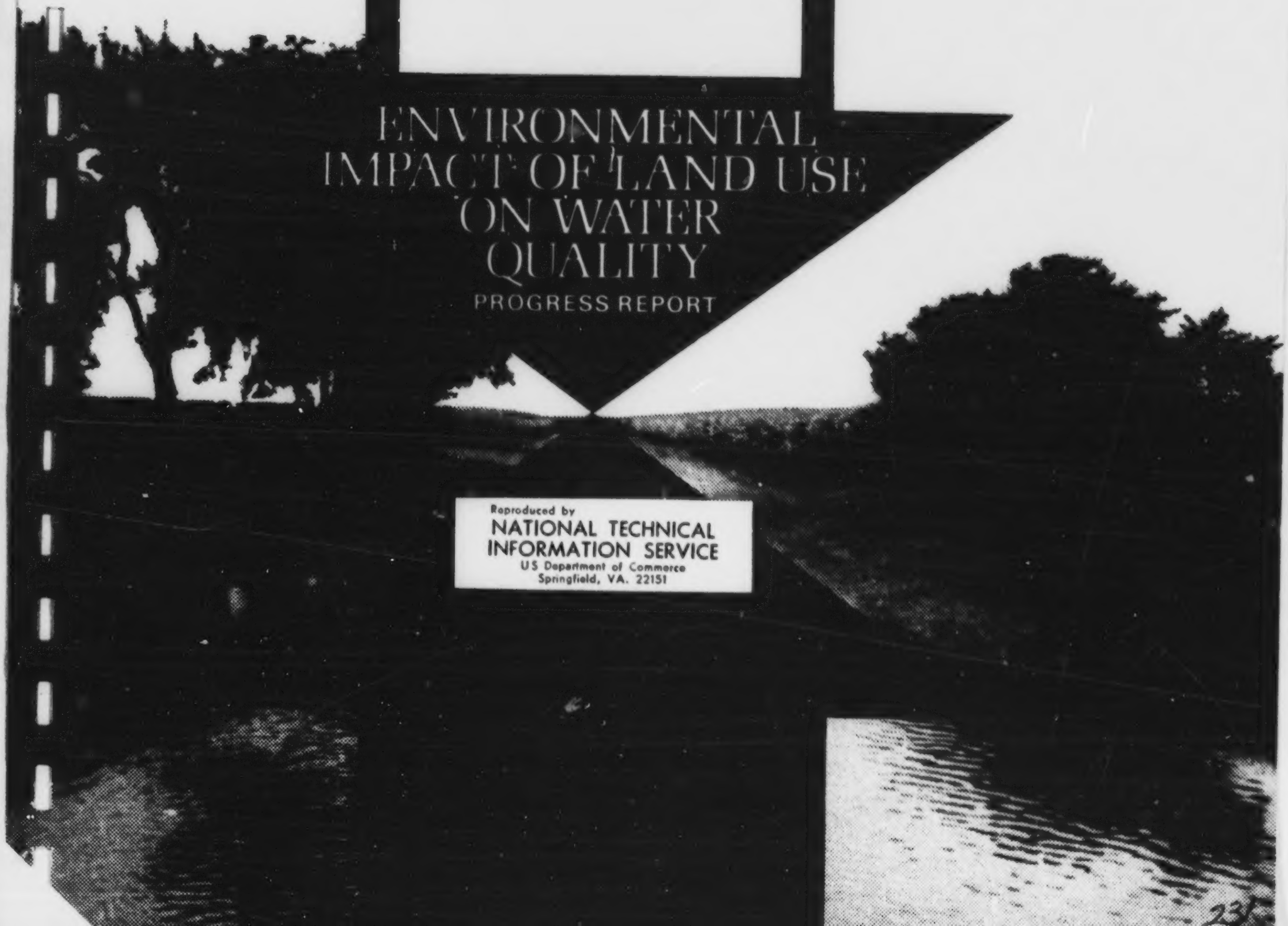

# ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY

PROGRESS REPORT

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This is a progress report on the Black Creek sediment control study, an Environmental Protection Agency funded project to determine the environmental impact of land use on water quality which is finishing its second full year of activities. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie.

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# ENVIRONMENTAL IMPACT OF LAND USE ON WATER QUALITY

(Progress Report)

Black Creek Project
Allen County, Indiana

by

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Project Director

**James Morrison**
Project Editor

Prepared for

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UNDER U.S. EPA GRANT NO. G005103

to

## ALLEN COUNTY SOIL & WATER CONSERVATION DISTRICT

U.S. Department of Agriculture, SCS, ARS
Purdue University

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# *Introduction*

The Black Creek sediment control study, an Environmental Protection Agency-funded project to determine the environmental impact of land use on water quality is finishing its second full year of activities. The project, which is directed by the Allen County Soil and Water Conservation District, is an attempt to determine the role that agricultural pollutants play in the degradation of water quality in the Maumee River Basin and ultimately in Lake Erie.

The Black Creek project was designed and developed by a consortium of the Environmental Protection Agency, the Soil Conservation Service of the United States Department of Agriculture, Purdue University, and the Allen County District. It is a response to allegations, first brought to the attention of Allen County residents at a Conference on the future of the Maumee River sponsored by Rep. J. Edward Roush in January of 1972.

At the conference, sediments and related pollutants were named as major contributors to the degradation of water quality in Lake Erie. It was further suggested that agricultural operations significantly increased the amount of sediment and sediment related pollutants.

The Black Creek Sediment Study, funded by a grant of nearly $2 million, is an attempt to discover the role that agricultural operations play in the pollution of the Maumee River and how that role can be diminished through the application of significant land treatment practices.

The project represents a multi-agency, multi-discipline approach to the total problem of non-point source pollution. It involves demonstration, through a program of accelerated land treatment under the direction of the Soil Conservation Service, applied research by Purdue University, administration by the Allen County Soil and Water Conservation District, and cooperation from a variety of state, federal, and local agencies.

The problem of non-point source pollution is becoming more and more important in the nation's overall effort to clean up the degraded streams and lakes. As major point sources of pollution such as industries and municipalities are brought under control and begin to contribute less and less of the total pollutant load, the necessity of controlling pollution which originates from small, hard to identify sources becomes more and more critical.

Our understanding of the mechanisms by which pollutants from diverse small sources is carried into the nation's waterways to become — in the aggregate — a large problem is not so advanced as is our understanding of the monitoring and control of point-source pollution. The Black Creek project is intended to provide significant data on which future decisions about efforts to control this type of pollution — if it indeed can be controlled at a cost that all citizens are willing to bear — can be based.

After two full years of operation, some significant results have been obtained. Not the least significant of the activities has involved the ability of the project agencies and other agencies and individuals to work together toward a common goal.

Particularly important to the successful operation of the project over two years has been the supervision and encouragement provided by the Environmental Protection Agency acting through Ralph Christensen, Administrator of Special Great Lakes Programs under which funding for the project was obtained and Carl Wilson, project officer.

Not directly under the project umbrella but furnishing great assistance and encouragement have been persons such as Allen County Cooperative Extension Agent Ernest Lesiuk. Indiana State Forester Larry Lichtsinn, and Wildlife Biologist George Kennedy. Mr. Lichtsinn and Mr. Kennedy are representatives of the Department of Natural Resources of the State of Indiana. Significant help and cooperation has also be afforded by local agencies such as the office of County Surveyor William Sweet, the Allen County Data Processing Department, the Allen County Plan Commission, and the Allen County Commissioners and Allen County Council.

Fourth District Congressman J. Edward Roush, whose conference inspired local individuals to undertake a project such as this, has continued to offer advice, support and assistance to the project. It has been gratifying during the past year to be able to exchange data and ideas with agencies such as the International Joint Commission on Great Lakes Water Quality and the Great Lakes Basin Commission.

## PREVIOUS REPORTS

The basic plan for the Black Creek Study is described in a work plan, *Environmental Impact of Land Use on Water Quality*, (EPA G005103) published in May of 1973. Standards by which this work was to be carried out were described in great detail in *Operations Manual Black Creek Study, Allen County, Indiana* (EPA Document 905-74-002). Progress during the first year of operation, June, 1973, to July, 1974, is reported in the first annual report on the Black Creek project. Research and demonstration efforts in the first year of the project centered on:

(1) A sociological survey of the Black Creek area
(2) Conservation planning and application
(3) Water Quality monitoring
(4) Water sample analysis
(5) Rainfall simulator studies
(6) Fish population studies
(7) Stream Bank studies
(8) Tillage Demonstration plots
(9) Modeling of the basin

Much of this work furnished a base on which activities which can be reported at the end of the second year were based.

During the second year of the project, many accomplishments were reported; however, certain problems have developed. It has become clear that technical assistance and

Land Treatment (Section 2)

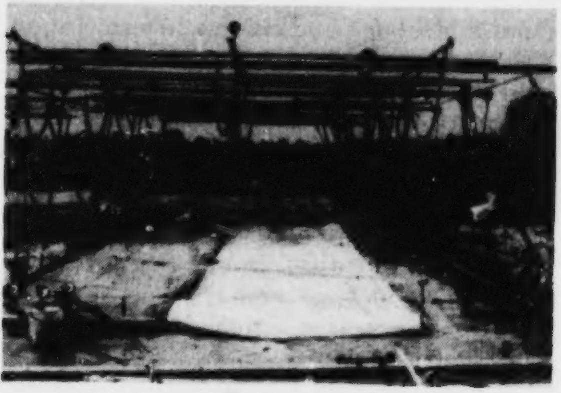
Land Treatment (Section 2)

financial incentives are not sufficient to convince every farmer or landowner to install needed conservation practices. This opens the question for future consideration of how land treatment is to be achieved if the research undertaken indicates that, in fact, land treatment can have a major impact on water quality.

Major research and project efforts to date are summarized below:

## Simulated Rainfall

Rainfall simulator test storms totaling five inches were applied to treatments on four soils in the Black creek watershed. The four soils were Haskins loam 1.8 percent slope, Nappanee clay loam 0.7 percent slope, Hoytville silty clay 0.8 percent slope and Morley clay loam 4.0 percent slope. Runoff and soil loss measurements were made in late spring on the following treatments: (1) check (crop residues as left by the harvester), (2) fall disk, (3) fall chisel, and (4) fall plow. These treatments were representative of conditions that occur in late winter and spring after the fields have undergone winter weathering. Results showed amount of residue left on the surface (as a result of type and amount of tillage) to have major effects on soil loss. Residues ranged from a low of 1 percent surface cover on the plowed plots to a high of 78 percent on the check plots. Also, residue remaining on the surface following a corn crop was about three times as great as following a soybean crop. Soil losses from fall disk and check treatments were similar and only 18, 17, 24, and 32 percent, respectively, of those from fall plowing on the Haskins, Nappanee, Hoytville, and Morley soils. Soil losses from fall chiseled land were 53, 58, 37, and 74 percent, respectively, of those from fall plowing on the same four soils.



Rainfall Simulation (Section 3)

Tillage Demonstrations (Section 4)

## Tillage Management

Demonstration of conservation tillage techniques was begun in the Black Creek Watershed in 1974. The main objective of the tillage demonstrations is to increase conservation tillage acreage in the Watershed through acquainting farmer cooperators and their neighbors with techniques and management practices necessary for the success of conservation tillage. The demonstrations included six soil types on four farms.

Tillage systems compared included fall plow conventional, spring plow conventional, fall chisel, shallow tillage (tandem disc), and "no-til" planting. All trials were for corn following corn in 1973. The 1974 growing season was unusual throughout, with excess rain in the spring, a severe summer drouth, and an early September frost. Yield information from 1974 may be of little value in predicting corn response to different tillage methods in more normal seasons.

In this first year of the trials, fall chiseling produced yields equal to or better than moldboard plowing in all trials except those on poorly drained Nappanee silt loam. Chiseled acreage appears to be increasing in the area and offers all but Amish farmers a soil conserving system adapted for widespread use in basic land preparation. Shallow tillage and "no-til" planting produced more variable corn yields than either plowing or chiseling on the poorly drained soils.

## Mulch Studies

The ditch bank-slope-mulch studies were completed in May, 1975. All mulch materials were effective in controlling erosion and in promoting the establishment of a grass cover. The stone mulch was slightly superior for erosion control.

The ditch bank stability studies have shown no significant erosion or accumulation during the first two years of observation. Channel stability studies are being initiated on three locations where evidence of channel scour or soil mechanics tests indicate potential for instability.

From September, 1974, to July, 1975, 480 cubic yards of material have been deposited in the desilting basin. Particle size of the material has yet to be determined. An intense storm on May 20, 1975, undoubtedly accounts for a large part of this volume of deposited material.

The May 20 storm produced nearly four inches of rain in two and one-half hours. Analysis indicates that the return frequency of the rainfall is less than 1 in 100 years. The storm produced ditch bank full-flows and general flooding throughout the level lake bed area. All of the installed conservation measures performed well during the subsequent runoff. While considerable erosion did occur, the infrequent nature of the storm must be recognized. It is probably not practical to expect to control all damage from such an intense and frequent event.

Mulch Studies (Section 5)

Fish Community Dynamics (Section 6)

## Community Dynamics of Fish

Recognition of the significance of seasonal movements into Black Creek from the Maumee River was an early conclusion of field studies. These movements are particularly striking in the spring but continue into the early fall with a different set of species. Bridge construction at Ward Road produced a major blockage and rip-rap, in association with stage-recorder weirs, temporarily blocked several of the tributaries of Black Creek. These two factors resulted in smaller numbers of fish in Black Creek during the spring migration (1975) with a particularly striking decline in larger fish. Fish populations also declined following bank reconstruction. The extent to which these communities did not regenerate due to the reconstruction or due to stream blockages mentioned above is not clear.

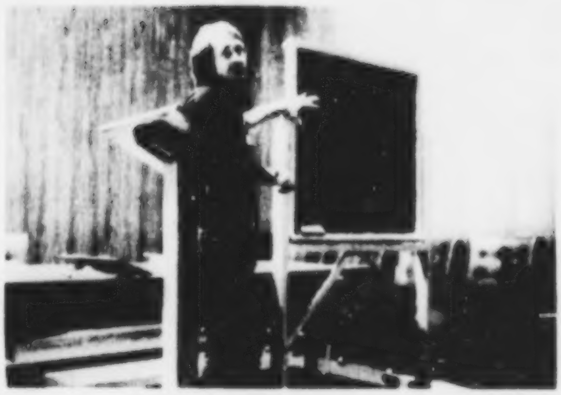
The most complex and stable fish community in the Black Creek Basin above Ward

Road is found in a small woodlot on the Wertz Drain. Because of the shading by the trees and the meandering nature of the stream in this area, temperature, oxygen, sediment, and nutrient regimes are more buffered than in channelized areas. This results in fewer algal blooms and a more stable, resident fish fauna. Studies of the robustness of Black Creek fish indicate that species which migrate into Black Creek from the Maumee River are similar to other midwestern populations of the same species. Black Creek residents, on the other hand, are much less robust than other populations, suggesting that the "health" of the fish of Black Creek is below that of more natural streams. All of these factors indicate the importance of both the stream basin and the terrestrial environment in the immediate vicinity in determining the structure of the fish community.

## Water Quality Monitoring

Water samples have been obtained on a weekly basis from 14 sites located on the Maumee River and Black Creek and its tributaries. Pump samplers installed at three sampling sites in the lower portion of the watershed enable detailed analysis of storm events and potential loadings of nutrients into the Maumee River. The following parameters are measured in all water samples: suspended solids, total nitrogen, total soluble nitrogen, ammonium-nitrogen, nitrate-nitrogen, total phosphorus, total soluble phosphorus, soluble inorganic phosphorus, total carbon, and total soluble carbon. A comprehensive survey of tile drain effluents was conducted in spring, 1974. The water quality data obtained suggest, in conjunction with other studies, that nutrient concentrations in subsurface flow exceed those found in surface runoff. The influence of agricultural and domestic drainage is readily apparent in the nitrogen and phosphorus analyses of water samples. In general, concentrations of different forms of nitrogen are similar in the Maumee River and the Black Creek area whereas phosphorus concentrations in the Maumee are elevated with respect to the watershed.

Water Quality Monitoring (Section 7)



Water Quality Monitoring (Section 7)

## Discharge into Lake Erie

As part of the study effort, historical data using U.S. Geological Survey records of stream flow and sediment transport near the mouth of the Maumee River and U.S. Weather Bureau records were analyzed. Graphs of sediment loads and discharge show high discharge and sediment movement in the winter months, December to March. The time frame for maximum hydrologic events from small catchments, however, does not coincide with that of the basin. The small catchments are more responsive to local, convective-type storms which occur later in the year. Runoff from the small catchments moves eroded soil down slopes, into intermittent waterways or into streams for subsequent transport by basin-wide storms. Runoff patterns are also influenced by extensive systems of subsurface drains which underlay most of the agricultural lands. Unfortunately, these drains also discharge a relatively small but almost continuous amount of suspended colloidal material. High discharge from the subsurface drains occurs in the winter months following complete thawing of the soil and in spring months following heavy rainfall.

The erosion-sedimentation process in a river basin can in general be divided into upland and in-channel phases. For the purpose of this study, the main channels of the Maumee River Basin are assumed to be in dynamic equilibrium so that the average annual sediment discharge into Lake Erie, except for manmade traps, equals the average annual erosion rate of the entire basin into the main channels. An erosion-sedimentation model based on rigorous theoretical considerations has been proposed for the upland phase. Consolidation of the results from all the small catchments within the basin into a comprehensive basin model will then be possible.

## Automatic Pumping Samplers

The automatic pumping samplers (PS-69) were installed at stations 2, 6, and 12 in the Black Creek Watershed and have been operating since February 22, 1975, March 17, 1975, and April 4, 1975, respectively. The stations are located in the lower section of the watershed to allow the sampler data to closely describe the water quality constituents movement from the watershed. The physical operation of the samplers has been very satisfactory.

The samplers are energized only while the stage in their respective stream is above the one foot level. While energized the samplers take a water sample every thirty minutes.

Data collected during three storms in late February and mid-March has been analyzed. This preliminary data indicates that in all cases the nutrients and suspended solids transported by a stream increases with increasing flow. More importantly the nutrients and suspended solids concentrations also increase with increased flow with the exception of ammonia and nitrate whose concentrations showed very little variation during a storm event.

**Sociological Studies (Section 8)**

## Sociological Studies

Attitudes of both Amish and non-Amish landowners were compared in an attempt to better understand how local people perceive pollution control and their willingness to participate in abatement programs. Both groups need to be understood in their cultural context. Second, the leadership structure among the non-Amish landowners was analyzed. Preliminary examination of the types of chemical fertilizers used by both Amish and non-Amish give indication to what landowners are applying to the land. These data will be useful in further understanding the nutrient content observed in water quality studies.

There are mixed feelings concerning conservation of soil. Both groups are equally divided among themselves as to the extent of soil problems that exist in the Black Creek. Farmers do not feel they should stand the cost of soil erosion programs alone and expect the federal government to stand between 25 to 50 percent of the cost. Education is considered by landowners to be the most effective tool to get cooperation on protecting water quality. Laws and federal controls are opposed and less than 15 percent felt financial incentives would be effective.

There are interesting differences between leaders and non-leaders in the non-Amish group. Those individuals selected by their peers as influential in agricultural affairs are more knowledgeable about pollution control and the role government can play in pollution abatement programs. Finally, there are differences in chemical fertilizers applied by Amish and non-Amish. Contrary to popular belief, the Amish use chemical fertilizers. Their types, however, are generally different than those analyses selected by non-Amish.

## Plans for Next Year

Several changes have been planned for operation of the Black Creek project during the coming year.

The Allen County Soil and Water Conservation District is giving serious consideration to adding an employee of the District whose primary function would be to follow-up on agreements made with landowners to see that the terms of the agreement are in fact carried out.

A change in the scope of the tillage demonstration effort will involve the renting of large tracts (up to 20 acres) and the carrying out of farming operations by a Purdue University employee. This will allow both replication of results and better control of the demonstration effort.

Management (Section 9)

Management (Section 9)

An automatic tile sampler is being installed near the Black Creek Watershed to investigate the influence of tile drainage systems on the total water quality of their respective streams. It is known that in some locations as much as 50 percent of the annual sediment loss is coming through the tile outlets. This indicates the vital need for understanding and describing the influence of subsurface drainage in order to complete a reliable watershed model.

The sampler will monitor a 10 inch diameter tile outlet which drains 63 acres of Hoytville silty loam soil. The entire 63 acres are nearly flat and very uniform in soil type. The uniformity of the field will greatly help in developing and verifying a reliable model for tile systems. Crop cover for the field is a standard corn-soybean rotation.

The area is not in the Black Creek Watershed because a uniform well managed tile system could not be located within the project boundary. The systems in the watershed either lacked a tile line layout record or were put in within the past three years. Even though the tile sampler site is not in the watershed it does well represent the tile drainage systems in the Black Creek Watershed.

The sampler will have the capability of collecting 72-500 ml water samples on a constant volume passed basis. The sampling rate will be approximately one sample per thirty minutes at maximum flow and no samples taken at zero flow with a linear response to intermediate flows. A flow record will be made continuously and an event mark on the flow record will designate when a sample was taken. The sampler station will have a 350 gpm pump in conjunction with a sump to prevent the tile outlet from being inundated during storm events. During low flows, the outflow will pass directly through the station with no pumping required.

The project will include three new objectives: (1) the development and operational evaluation of an automatic, real-time system for acquisition and analysis of hydrometeorological data, (2) the development of a distributed parameter watershed model to provide real-time hydrologic prediction of stream flows in the Black Creek watershed, and (3) automation of existing procedures for collecting environmental data from the watershed.

The additional electronic transducers required to provide computer compatible signals corresponding to standard meteorological variables have been ordered. Permission has been obtained from the affected landowners to locate these additional instruments in the catchment. The installation of required underground cabling and a direct telephone link between the watershed and the Agricultural Engineering building on the West Lafayette campus is currently underway. The design of special electronics to interface the field instrumentation, both new and existing, to a minicomputer system on the Purdue campus is nearly completed.

The schedule of accomplishments anticipates initial operation of the primary meterological station and the telephone transmission of its data to West Lafayette in late October or early November. Installation of additional field equipment to provide computer control of water sampling will proceed within a month after successful completion of initial testing on the integrity of the data link between the watershed and campus. Expansion of the network of field instrumentation using radio telemetry is planned for the summer of 1976.

# *Getting Treatment on the Land Not Always Simple*

**SECTION 2**
**Land Treatment Planning and Application**

By
Thomas D. McCain
Darrell E. Brown
Stanley W. Steury

Conservation planning and application has been underway for two years on the Black Creek project. Total accomplishments now stand at 105 cooperators, 83 conservation plans and 75 contracts. As of June 30, 1974, there were 24 non-Amish and 6 Amish contracts. The accomplishments for the current year, ending June 30, 1975, reflect a 200 percent increase in Amish contracts and a 138 percent increase in non-Amish contracts. The staffing of a second planner in August, 1974, accounted for this significant increase. This now accounts for 44 percent of the original (estimated) goal for farms under contract to date.

Black Creek represents only 4 percent of the land area of Allen County. The staffing level for the Soil Conservation Service Field Office however is more than 55 percent devoted to Black Creek activities. However, with the acceleration of planning and application in Black Creek, the measurable land treatment accomplishments for the field office reflect a much higher ratio. Therefore it can be concluded that intensive manpower inputs directly results in measurable accomplishments.

In the initial work plan preparation, considerable effort went into establishing conservation planning and land treatment goals. A projection of staffing levels was reflected in the work plan which was prepared in 1973. We can now report actual accomplishments and man-power needs as they relate to the original estimate.

More than twice the normal number of man hours is required for completion of each individual Black Creek plan. This extra time requirement can be attributed to much greater detail necessary in preparing cost estimates, the involvement of a planner with the monetary aspects of this contract, and the decision making processes by the landowner. In normal Soil Conservation Service conservation planning, a completed plan may include a listing of alternatives selected by the landowner; however, Black Creek contracts include a conservation plan with only decisions not alternatives. There were seven conservation plans with alternatives awaiting the landowners final selection of decisions in Black Creek on June 30, 1975. These plans, representing mostly Amish ownership, may become contracts before the Black Creek program is terminated.

A review of the conservation practices originally listed in table A-10 of the work plan and the charts in section 9 will show the Soil Conservation Service's projected goals and actual accomplishments to date. Additional committment amounts beyond the actual accomplishment for most individual practices reflects a backlog yet to be completed. Total committments to date can therefore be related to yearly goals by noting the position on each chart. We have concluded that the number of landowners who are potential cooperators should be increased. The original work plan estimate of 170 tracts (148 of which were needed as "new" cooperators to make 100 percent) were reviewed by the Soil Conservation Service-Soil and Water Conservation District staff in June, 1975. A section by section count of landowners with five acres or more now totals 200. There were 32 cooperators prior to the Black Creek program. The goal for new cooperators could now be increased to 168; however, following our present policy of signing up all land units as new cooperators would increase the goal to 200.

Goals represented on table A-10 are idealistic and represent estimated treatment levels necessary to attain 100 percent coverage of the 12,000-acre Black Creek area. At the mid-way point in the Black Creek program, we can recognize that many of these land treatment goals will be unattainable. Basic educational needs, a greater time span required for acceptance and/or installation by landowners, and the somewhat unbalanced practice goals appear as three items we now know a great deal more about.

At this point in Black Creek history our successes in both planning and application are exciting. Many innovative ideas and opportunities are extended to the Black Creek participants that are not a part of our traditional Soil Conservation Service operations in the remaining portions of Allen County.

Developing workable and rapidly acceptable land treatment practices for the Black Creek participants involves modification of the practice specifications or cost-share rates by the Allen Soil and Water Conservation District board of supervisors. Since Black Creek is administered locally, many innovative changes have been proposed by the staff, approved by the board and become workable solutions with a minimum of delay. Shifts in program emphasis have been effected by this procedure as the board reviewed progress of various land treatment goals for the watershed. Table 2-1 briefly explains the modifications adopted by the board. As of July 14, 1975, modifications have been suggested and approved for 15 of the 34 application practices in the Black Creek handbook.

Although there is no numerical or percentage breakdown of practices completed on the rolling uplands versus flat, lake bed soils area of the Black Creek watershed, it is generally concluded that the most significant early progress was made with the most cooperative, progressive lake bed farmers. Many of these successful farmers were cooperators long before the Black Creek program started. There were, however, several upland plans developed inthe first year that have resulted in considerable erosion control work on farms north of Indiana Highway 37, which is the

## Table 2.1 Changes in Practice Specifications and Cost Share

| Practice | Spec. Change | Cost-Share Change | The Change Is | Reason |
|---|---|---|---|---|
| Conservation Cropping System | Yes | No | Change to pay only on farms where a change in rotation is made. | This was a give-away to landowner on flat land that required no changes to meet specifications. |
| Crop Residue Management | Yes | Yes | Change to pay only on farms where a change in rotation is made. 70% of $1.50/ac. to 80% of $1.50/ac. | To make a little more incentive and to stop give aways for no change. |
| Diversion | No | Yes | Reduce inlet cost-share for $150.00 each to $50.00 each. | This puts cost of tile back on the tile practice specifications and cost-share. |
| Farmstead and Feedlot Windbreak | No | Yes | Increase from $80.00/ac. to $300.00/ac. | Incentive to buy larger trees. |
| Grassed Waterway | No | Yes | To include payment on a cubic yard or lineal foot basis. | Make excavation costs easier and faster. |
| Minimum Tillage | Yes | Yes | Increase base rate to $7.00 /ac. Have three options: 80%, 65%, 30%. | Incentives to get more minimum tillage. |
| Pasture Planting | No | Yes | Price unit from $70.00/ac. to $100.00/ac. | More incentive to plant permanent pasture. |
| Pond | No | Yes | Increase cost-share on seeding to 80% of $75.00/ac. Increase seed and mulch to 80% of $150.00/ac. | Make rates uniform with other seeding practices. |

Table 2.1 Changes in Practice Specifications and Cost-Share (continued)

| Practice | Spec. Change | Cost-Share Change | The Change Is | Reason |
|---|---|---|---|---|
| Strip Cropping | Yes | No | Make payments on consecutive years on same area. | More incentives to apply practice. |
| Terraces-Gradient | No | Yes | Reduce inlet cost-share for $150.00 each to $50.00 each. | This puts cost of tile back on the tile practice specifications and cost-share. |
| Terraces-Parallel | No | Yes | Reduce inlet cost-share for $150.00 each to $50.00 each. | This puts cost of tile back on the tile practice specifications and cost-share. |
| FOLLOWING CHANGES EFFECTIVE JULY 14, 1975 | | | | |
| Grassed Waterway | No | Yes | Increase cost-share to 90% | Added incentive for more waterways. |
| Pasture Management | No | Yes | Increase cost-share from 65% of $18.00/ac. to 65% of $50.00/ac. | Added incentive and help to cover cost of increased fertilizer and lime. |
| Pond | Yes | Yes | Allow construction of ½ ac. livestock ponds and pay 75%. Also remove $1800.00 hold down on other ponds and pay maximum of 60% of estimate. | Incentive for more ponds. |
| Contour Strip Cropping | No | Yes | Increase unit price from $5.00 per acre to $10.00 per acre. | Incentive for more of the practice. |
| Terraces | No | Yes | Increase cost-share to 90% | Incentive for more of the practice. |
| Fencing | Yes | No | Change specification to allow 1 barb on woven wire or 4 barbed wire fence. | To make a more workable specification. |

## Table 2.1 Changes in Practice Specifications and Cost-Share (continued)

| Practice | Spec. Change | Cost-Share Change | The Change Is | Reason |
|---|---|---|---|---|
| Field Border | No | Yes | Reduce cost-share from 70% to 60% | Make payments to end of project more equitable. |
| Diversions | No | Yes | Increase cost-share to 90% | Incentive for more of the practice. |
| Livestock Exclusion | Yes | Yes | Start paying for excluding livestock from woods. Pay 70% of $4.00 per acre. | Encourage landowners to keep livestock out of woods. |

approximate upland-flatland boundary. The most significant land treatment progress during the first and second years were attributed to group construction mostly along the western and southern half of the Black Creek area.

The Indiana Highway 37, beech-ridge transition between the lower lake bed soils and the rolling uplands, is associated with a change in landownership patterns. Generally, the 7500 acre area south of Indiana Highway 37 is owned and operated by full-time, progressive farmers with highly mechanized equipment and livestock generally raised in confinement. These full-time farmers have little or no use for meadow in rotation or pastures on these flat, black, poorly drained soils. The rolling uplands, particularly in the 2,500 acre northwest quarter of Black Creek are predominately owned and farmed by Amish. These lands being farmed by "horse" power contain many small herds of livestock on pasture. Amish landownership represents about one-third of the recognized farming units in the Black Creek watershed. In terms of numbers of people involved in operation of Black Creek farms, the Amish with their very large families would have more people committed to production. Many Amish have a side occupation (operation of saw mill, wheel fabrication, harness shop, etc.) on their farms.

The remaining rolling upland in the 2000-acre northeast quarter of the watershed is farmed partly by Amish and partly by tenant operators on lands they do not predominately own. Absentee landowners are more difficult to motivate. Likewise successes with these people comes through interested tenants willing to invest their own time and labor in someone else's land.

The greatest number of conservation plans have been developed with the more progressive farmers, many of whom have been previous cooperators of the Allen County Soil and Water Conservation District. Other less progressive farmers were basically motivated at an early stage by group application in their own area. A system of planning in priority areas as outlined in the work plan, has been a basic objective of our efforts. However, we have worked throughout the watershed with planning and application wherever there has been specific requests by landowners for assistance.

High priority areas such as the Upper Wertz watershed (northwest quarter) are special target areas for group work involving nearly 100 percent Amish ownership. Motivating these people takes more time and perseverance (by approximately 3-4 fold) than the efforts directed toward group application in lower Black Creek. However, the final accomplishments in these upper more erosive watersheds will ultimately result in a more diverse and meaningful pattern of land treatment than the group work completed on the flatter lands south of Indiana 37. Much stronger educational efforts are needed with these less progressive landusers on the rolling uplands before they are ready to assume contract responsibilities for their farms.

Early work with several prominent Amish landowners in the Upper Dreisbach watershed northwest of Harlan has resulted in application of many conservation practices that now stand as good examples for other Amish to observe. Nearly one-half of the Amish landowners have completed contracts compared to approximately one-third of the non-Amish. Considering the Amish ownership of the predominately more erosive watershed areas, this remaining planning goal will require intensive educational and motivational efforts.

Although not a significant portion of Black Creek had yet been credited as "land adequately treated" on June 30, 1975, it is generally agreed that 65-70 percent of the lake bed soils are presently adequately treated (according to Soil Conservation Service standards) and only 30-35 percent of the rolling upland could be considered adequately treated without further application of conservation measures. Woodland and pastures along with cropland treatment needs have posed special problems in converting Amish to manage their farms according to "land adequately treated" standards.

Nearly all landowners in the 580-acre Upper Wertz drainage area were initially disinterested in both the group and individual application practices being offered by the Black Creek program. They failed to see any benefits that would accure to their farms and generally resented changes that would be necessary in their traditional farming operations. Even economic incentives of high cost-sharing rates had little effect on their initial interest in conservation land treatment. Through a four-month period of repeated contacts and several group meetings, these Amish people agreed as a group to support the construction of a large grass waterway. Since that time they have agreed to go ahead with severalother treatment practices associated with the grass waterway; however, many landowners have yet to select all of the proper practices to complete their individual contracts. We hope that after completion of the group waterway many of these landowners in the Upper Wertz area will adopt contracts on the remaining portions of their land.

The success in getting something underway with the Amish is due to many personal "one-to-one" contacts with the landowners. Once an understanding and an acceptance of agency personnel is gained by the landowner, progress can be made. It seems that many of these landowners are reluctant to be first to try something new or different. Once a practice has been tried, others are more willing to install the same practice and the original landowners may continue to apply more of the same.

Many of the landowners north of Indiana Highway 37 have been reluctant to install grass waterways, terraces, diversions and other practices that would adapt well to this area. Landowners in the flatter sections of the watershed have been reluctant to carry out some of the cultural practices (minimum tillage, residue management, etc.) that are needed.

One major success has been the establishment of the field border strips. Most of these 16-foot wide vegetated strips have been established along open ditches. Some borders have been established along woods or along other areas where there is a break in the natural slope of the land.

Although an unknown amount of fall chisel plowing was done by landowners in the fall and winter of 1973-74, actual accomplishment information was obtained by Purdue for the following 1974-75 dormant season. All indications are that there will be a further increase in chisel plowing for the 1975-76 season. Part of this increase can be attributed to the emphasis on minimum tillage and the favorable cost-share payments. Many landowners are still reluctant to limit the number of tillage operations in the spring. Farmers believe they must work the land two or three times in the spring — mostly for weed control.

One major problem is a tendancy by some landowners, who are under contract, to put off installation or "carry over" practices from one year to the next. Part of the problem is a lack of timely follow-up by field personnel. Some of these practices need to be planned well in advance, and the landowner must be reminded early so he can plan for this work to be completed in the proper season. Some practices need to be done at crop planting or crop harvest time. During these busy times many practices get assigned a lower priority by the farmer. This problem of completion delay is seldom on a required practice — usually it involves some practice which was supplemental to the requirements of the contract.

After many difficult conservation planning sessions, it has become apparent that one item needs to be recognized. In the project area there are landowners who may agree to a complete conservation plan and long-term contract even though they are not enthusiastic about the benefits of the land use changes or land treatment practices. They may sign the contract for several reasons:

(1) To satisfy a spur of the moment need created by the salesmanship of the planner — a need which they are later unwilling or unable to meet.

(2) To try to shift the attention of planners and other project workers to other areas — so they won't be bothered anymore.

(3) To assure themselves that they will get a few items that they truly want.

The problems created by contracts signed for the above reasons is that the landowners may try to delay application of scheduled practices, or, he may not be interested enough to do a good job. For example, good pasture management techniques were mostly unused before this project and pastures are still being mistreated even on farms under contract. Landowners simply have not taken enough interest to manage them wisely. Education is needed badly and good examples plus a study of pasture economics (carrying capacity) would be the best approach.

Other examples of waning interest are easy to find throughout the watershed such as, terraces, diversions, and waterways where the seeding failed and serious erosion has occurred in the first year after construction. Simply, not enough effort was put forth by the landowner to get a good stand. Overgrazing of established waterways has occurred because of failure to install fences for livestock exclusion. This has become a frequent follow-up problem and may require additional violation "citations" to be issued by the Soil and Water Conservation District board.

Treatment alternatives for cropland having an erosion hazard are developed for the Black Creek cooperators by the use of the Universal Soil Loss Equation. Adequate treatment will, as a minimum, control soil loss within the tolerable limits for each soil type and erosion group.

Planners have access to soils information for each farm as they work with the land users in developing cropping systems capable of holding the average annual soil loss to levels within the tolerable limits. Many times a combination of management practices (rotation, residue use, minimum tillage, contouring, etc.) must be combined with one or more mechanical practices (diversions, terraces, grass waterways, etc.) to reduce slope length in accomplishing the soil loss goal on each farm.

Most soils in the Black Creek area have annual tolerable loss limits of 3-4 tons depending on their inherent ability to retard erosion. The more erodible (heavier clay) soils have a lower "T/K" index. This coupled with other on-site data (slope length and percent) and the rainfall factor for Allen County assists the planner in computing the cropping management factor. This final numerical "c" value is used in selecting the rotation most nearly meeting the needs of the farmer and the soil.

The universal soil loss equation is where:

$$A = RKLSCP$$

**A** is the computed soil loss per year per unit area of land. It is computed as tons per acre.

**R** is the average annual rainfall-erosion index or the average annual erosive force of rainfall. An R value of 160 is assigned to Allen County, Indiana. R values are found on figure 2.1.

**K** is the soil erodibility factor. It is a measure of the rate at which a soil will erode expressed as tons per acre per year per unit of R for a 9% slope 72.6 feet long under continuous cultivated fallow. K values for the soils in Indiana are found in figure 2.2.

**L** is the slope length factor. It is the ratio of soil loss from a specified slope length to that from a slope length of 72.6 feet long, which is the slope length for the K value in the equation. A slope length of 72.6 feet long has a factor value of 1. L is determined in the field.

**S** is the slope gradient factor. It is the ratio of soil loss from a specific slope gradient to that from a gradient of 9 percent, which is the slope gradient specified for the K value in the soil loss equation. A slope gradient of 9 percent has a factor value of 1. S is determined in the field.

**L** and **S** are usually handled in combination. The soil loss ratio — SL, can be read directly from the slope-effect chart, figure 2.3.

**C** is the cropping management factor. It is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from the land in continuous fallow. Continuous fallow has a factor value of 1 in the equation. Cropping management factors (C) for common rotations used in Black Creek are found in figure 2.4.

**P** is the conservation practice factor. It is the ratio of soil loss from a specified conservation practice to that from up-and-down hill tillage operations. Up-and-down hill tillage has a factor value of 1 in the equation.

Soil loss tolerance (T) is not found in the equation but is important to the use of the equation in practical field application. It is the maximum soil loss in tons per acre per year which can be tolerated on a specific soil and still permit a high level of crop production to be sustained economically and indefinitely. This does not necessarily equate to water quality levels in streams.

T amounts, in tons per acre per year, have been established for all soils in Black Creek and are found in figure 2.2 together with the K values for the soils. T/K values are also listed in the table. The T/K is simply the T value divided by the K value for a specific soil. These elements are used as a T/K value on the calculator for Planning Conservation Systems.

The soil loss calculator (slide rule) is used in combination with the reference tables listed to determine proper land treatment alternatives. (table 2.2)

As an example, a cropping system computed on Joe Graber's farm in the rolling uplands along the western edge of Black Creek watershed has 5 percent slopes in field number 2 with average slope lengths of 90. The T/K value for this eroded Morley silt loam is 7. He farms generally across the slope (nearly contoured). The slide rule indicates the cropping value of 0.165. Using Joe's present crop rotation of row-small grain-meadow-meadow (1-1-2) with spring plow and removing silage from the corn ground his actual cropping factor is 0.060. Therefore averaging the soil loss over this four year rotation Joe could expect a loss of only slightly over one ton per acre compared to the tolerable limit of three tons to maintain productivity of his land.

Another example is on Duyane Amstutz's farm, where his rotation is a 2-1, that is, 2 years row crop, 1 year wheat, and fall plow. On the east part of field 1 we have an area with 2-6 percent slopes averaging 500 feet long. Field No. 1 is shaped like a concave bowl, making farming cross-slope or nearly contour not difficult but inef-

## Table 2.2 Calculated Practice Fact or Based on Percent Slope

| Percent Slope | Practice Factor Value | | |
|---|---|---|---|
| | Contouring | Contour Strip Cropping | Terracing Plus Contouring |
| 1.1 - 2.0 | .6 | .3 | .6 |
| 2.1 - 7.0 | .5 | .25 | .5 |
| 7.1 - 12.0 | .6 | .3 | .6 |
| 12.1 - 18 | .8 | .4 | |
| 18.1 - 24 | .9 | .45 | |

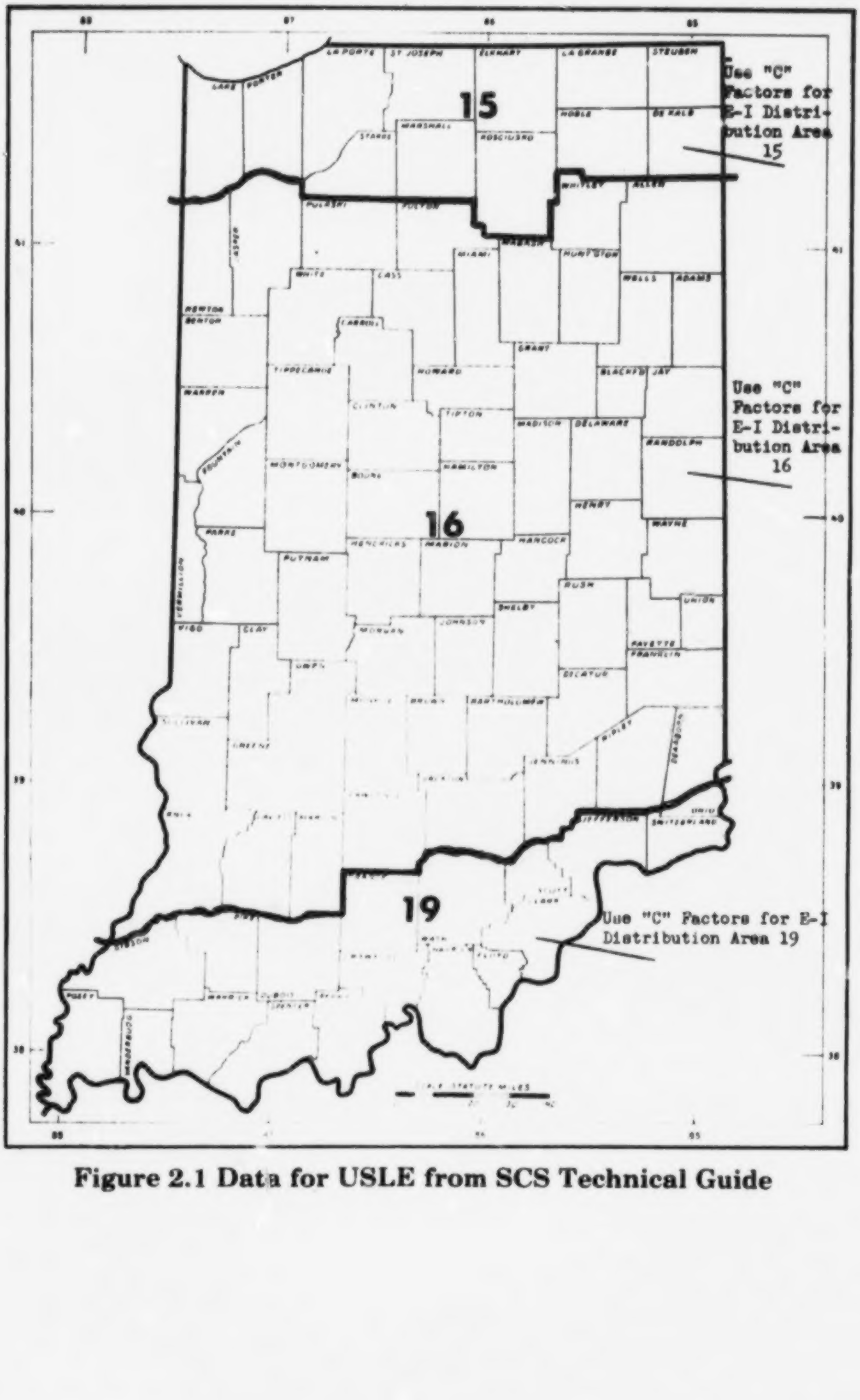
fective as far as soil loss is concerned. A small portion of the field has 6-12 percent slopes. The T/K value of this moderately eroded Morley silt loam is 7. The slide rule indicates a value of 0.048. Using Duyane's present rotation of 2-1 with fall plow his crop factor is 0.264. Therefore, the soil loss averaged over a 3 year rotation is about 16 tons annually per acre.

Since altering any one or a combination of factors in the soil loss equation can bring about favorable results, the cooperator, after considering all the alternatives, decided to break down the slope length by using grassed backslope parallel terraces. By installing these on 170 feet intervals his soil movement (loss) is reduced to just under the three ton tolerable loss limit. These terraces temporarily pond runoff behind each ridge letting the silt settle in place while clean water is going out through a field tile. This tile outlet, of course, helps drain the land after the surface flush has past.

A third example is on Henry Armbruster's farm located in the lower portion of the watershed, near the point where Black Creek outlets into the Maumee River. The major soil type is Nappanee, which is a nearly level, deep, somewhat poorly drained, depressional soil with a T/K value of 6. Conventional tillage (plow and disc) is performed generally up and down the slope which is two percent with a length of approximately 450 feet. Henry fall plows all his corn ground. The cropping management (slide rule) factor for this land is 0.85. This factor would limit his cropping rotation to a 1-1-1 (or 1 year row crop, one year small grain, and one year hay or pasture). Henry elected to not fall plow but leave the 4000-6000 lbs of corn stalk residue from the 120 bushel average yield on the soil surface during the erosive winter and spring months and use minimum tillage (chisel plow with one discing) in the spring. With this change in management techniques he can now safely go to a 3-1 rotation (3 years row crop, 1 year small grain with clover intercrop) and still be within the allowable soil loss for this soil type. Prior to this change in cultural practices Henry was loosing on the average 11 tons of soil per acre per year on the same ground.

RAINFALL EROSION-INDEX DISTRIBUTION CURVE MAP

INDIANA


15
16
19
LA PORTE
ST JOSEPH
ELKHART
LA GRANGE
STEUBEN
LAKE
PORTER
NOBLE
DE KALB
STARKE
MARSHALL
KOSCIUSKO
WHITLEY
ALLEN
PULASKI
FULTON
JASPER
MIAMI
WABASH
HUNTINGTON
WHITE
CASS
WELLS
ADAMS
NEWTON
BENTON
CARROLL
GRANT
HOWARD
BLACKFORD
JAY
TIPPECANOE
WARREN
CLINTON
TIPTON
MADISON
DELAWARE
RANDOLPH
FOUNTAIN
MONTGOMERY
BOONE
HAMILTON
HENRY
WAYNE
PARKE
PUTNAM
HENDRICKS
MARION
HANCOCK
VERMILLION
RUSH
UNION
VIGO
CLAY
MORGAN
JOHNSON
SHELBY
FAYETTE
FRANKLIN
DECATUR
SULLIVAN
GREENE
RIPLEY
DEARBORN
JENNINGS
JEFFERSON
OHIO
SWITZERLAND
GIBSON
POSEY
VANDERBURGH
WARRICK
DUBOIS
SPENCER
PERRY
FLOYD
SCALE STATUTE MILES

Use "C" Factors for E-I Distribution Area 15

Use "C" Factors for E-I Distribution Area 16

Use "C" Factors for E-I Distribution Area 19

Figure 2.1 Data for USLE from SCS Technical Guide

| | 1&2 Eros | | | 3 Eros | |
|---|---|---|---|---|---|
| Soil Type | "K" Value | "T" Value | "T/K" Value | "T" Value | "T/K" Value |
| *Belmore | .32 | 3 | 9 | 2 | 6 |
| Blount | | | | | |
| Bono | | | | | |
| Brookston | | | | | |
| Carlisle | | | | | |
| Chelsea | | | | | |
| Crosby | .37 | 3 | 8 | 2 | 5 |
| Del Rey | | | | | |
| Eel | | | | | |
| Fox | .32 | 3 | 9 | 2 | 6 |
| Genesee | | | | | |
| Haskins | | | | | |
| Hoytville | | | | | |
| Lenawee | | | | | |
| *Martinsville | .37 | 4 | 11 | 3 | 8 |
| Mermill | | | | | |
| Miami | .37 | 3 | 8 | 2 | 5 |
| Montgomery | | | | | |
| *Morley | .43 | 3 | 7 | 2 | 5 |
| *Nappanee | .49 | 3 | 6 | 2 | 4 |
| *Oshtemo | .24 | 3 | 13 | 2 | 8 |
| Pewamo | | | | | |
| Plainfield | .17 | 5 | 29 | 5 | 29 |
| *Rawson | .37 | 3 | 8 | 2 | 5 |
| Rensselaer | | | | | |
| *St. Clair | .49 | 3 | 6 | 2 | 4 |
| Shoals | | | | | |
| Tawas | | | | | |
| Wallkill | | | | | |
| Washtenaw | | | | | |
| Westland | | | | | |
| Whitaker | | | | | |
| Willette Muck | | | | | |

*Soil found in Black Creek watershed.

**Figure 2.2 Data for USLE from SCS Technical Guide**

SLOPE EFFECT CHART

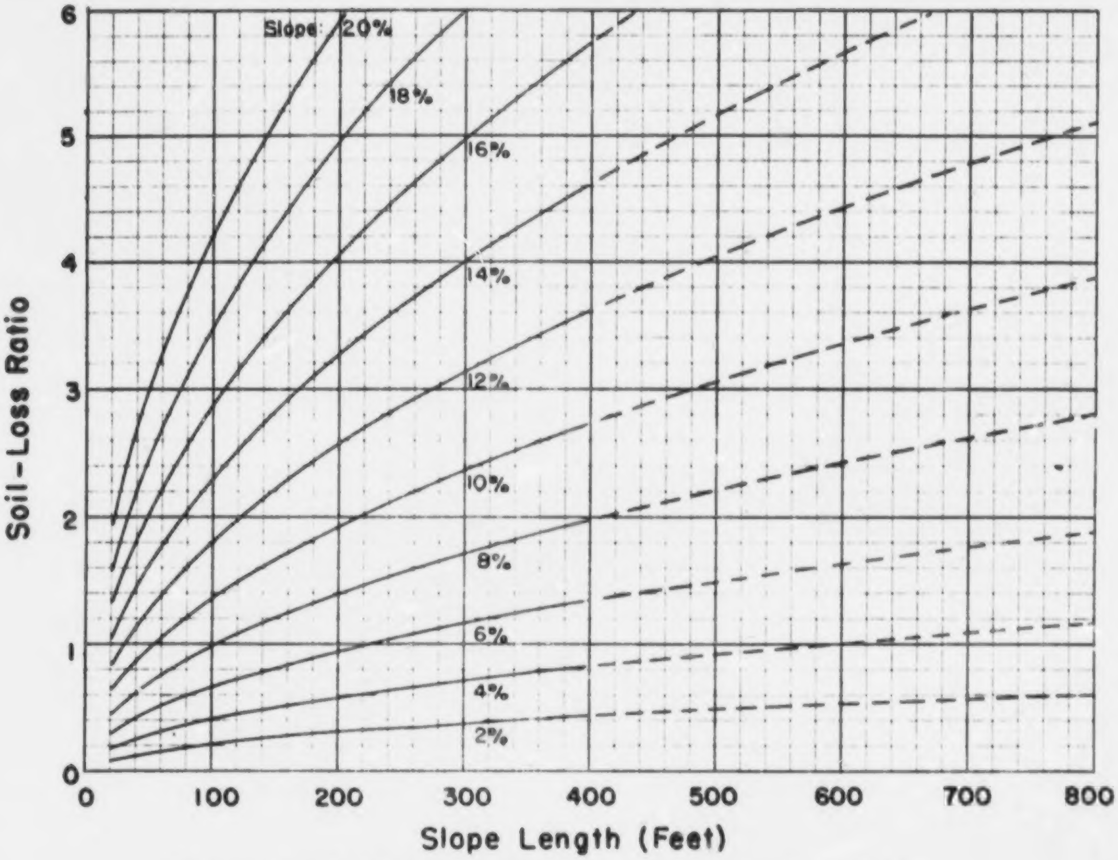


**Figure 2.3 Data for USLE from SCS Technical Guide**

"C" CROP MANAGEMENT FACTOR VALUES FOR CENTRAL INDIANA
(E.I. DISTRIBUTION AREA 16)
Ratio of Soil Loss from Cropping Management Systems to Loss from Continuous Fallow

| Crop Sequence | Fall Plow Conv. Till | | Spring Plow Conv. Till | | Plow Plant Wheel Track Plant | Minimum Tillage Methods | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Systems such as Till Plant, Chisel Plow & Rotary Strip Tillage 2/ | | | | | Systems such as Fluted Coulter & Slot Planting 3/ | | | | |
| | Crop Yields - High 1/ | | | | | Crop Residue on Surface | | | | | Crop Residue on Surface | | | | |
| | RdR | RdL | RdR | RdL | RdL | 1000-2000 | 2000-3000 | 3000-4000 | 4000-6000 | 6000+ | 1000-2000 | 2000-3000 | 3000-4000 | 4000-6000 | 6000+ |
| 1 Cont. Corn | .484 | .388 | .455 | .354 | .250 | .346 | .238 | .185 | .129 | .079 | .276 | .188 | .127 | .070 | .030 |
| 2 Cont. Corn RdR, Cover Crop RdL | | | .392 | | .331 | .231 | .224 | .205 | .193 | | .238 | .184 | .158 | .151 | |
| 3 RRRGx | .358 | .309 | .341 | .269 | .194 | .185 | .139 | .112 | .087 | .064 | .150 | .109 | .081 | .054 | .037 |
| 4 RRGx | .311 | .264 | .270 | .236 | .176 | .124 | .098 | .088 | .070 | .058 | .103 | .079 | .063 | .048 | .039 |
| 5 RRRGM | .239 | .195 | .199 | .164 | .117 | .148 | .110 | .090 | .070 | .052 | .120 | .088 | .066 | .044 | .030 |
| 6 RRRGMM | .200 | .163 | .167 | .137 | .098 | .128 | .092 | .076 | .059 | .044 | .101 | .074 | .055 | .037 | .026 |
| 7 RRGM | .174 | .150 | .143 | .123 | .088 | .094 | .075 | .064 | .054 | .045 | .078 | .061 | .049 | .037 | .030 |
| 8 RRGMM | .140 | .121 | .115 | .099 | .071 | .076 | .061 | .052 | .044 | .036 | .063 | .049 | .038 | .030 | .025 |
| 9 RRGMMM | .119 | .101 | .097 | .083 | .060 | .064 | .051 | .044 | .037 | .031 | .054 | .042 | .035 | .026 | .021 |
| 10 RGM | .090 | .082 | .078 | .070 | .053 | | .047 | | | | | .041 | | | |
| 11 RGMM | .069 | .063 | .060 | .054 | .040 | | .036 | | | | | .032 | | | |
| 12 RGMMM | .056 | .051 | .049 | .044 | .033 | | .030 | | | | | .026 | | | |
| 13 RGMMMM | .047 | .043 | .041 | .037 | .028 | | .025 | | | | | .022 | | | |
| 14 GMMMM | | .019 | | .015 | | | | | | | | | | | |
| 15 G-R (double crop) | (Plow for G) | | | | | | | | | | | | .123 | | |
| 16 G-R (double crop) | (Disk for G) | | | | | | | | | | | | .071 | | |

Where there is more than one year of row crop, the last year of row crop is soybeans when followed by small grain. Where meadow is included in the rotation, the first year corn after meadow is planted in 2000-3000 pounds of sod residue for minimum tillage. Select the column for the amount of corn stover residue on the surface after planting for second year corn and thereafter.

1/ Yearly average corn yield exceeds 75 bushels per acre and meadow yield is 3 tons or more per acre.

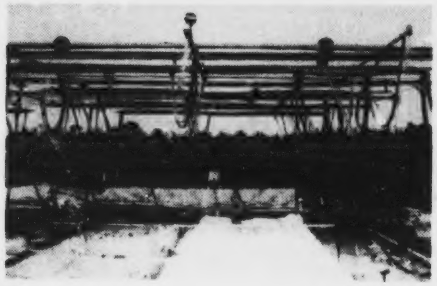
2/ Includes tillage systems which leave residues on 66% or more of the soil surface after planting.

3/ Includes tillage systems which leave residues on 90% or more of the soil surface after planting.

Figure 2.4 Data for USLE from SCS Technical Guide

# *Fall Tillage Has Impact on Soil Loss*

**SECTION 3**
**Simulated Rainfall Tests conducted in Black Creek Watershed in 1974 and 1975**



By
J. V. Mannering
and C. B. Johnson

This report primarily summarizes the results of simulated rainfall tests in 1974. Although some field testing was accomplished in late spring and early summer of 1975 there remains appreciable laboratory analyses to be completed before the results can be summarized. The research conducted in 1974 and reported herein evaluates the influence of cropping and tillage practices on runoff and soil loss from cropland. This work falls under objective 4 page B-23 and is further described on page B-24 in the project work plan. (EPA-G005103)

## 1. PROCEDURE

Test sites were prepared after harvest in the fall of 1973 on areas that had been cropped to either corn or soybeans. Earlier surveys had shown that almost 60 percent of the 12,038 acre watershed is planted to these two crops annually. Soils, slopes and prior crop are identified in table 3.1.

The treatments applied during the fall of 1973 included:

(1) *Check* — No tillage applied after harvest of crops. All residues left on the surface.
(2) *Disk* — Light disking (2-3 inches deep) in the fall—slight incorporation of residues.
(3) *Chisel* — Chiseling (6-8 inches deep) in the fall. Some incorporation of residues.
(4) *Plow* — Plowing (6-8 inches deep) in the fall. Nearly all residues buried.

All treatments were replicated once.

## Table 3.1 Identification of Test Locations

| Location | Soil Type | % Slope | Prior Crop |
|---|---|---|---|
| Richard Yerks | Haskins loam | 1.76 | corn |
| Virgil Hirsch | Nappanee clay loam | 0.66 | corn |
| Virgil Hirsch | Hoytville silty clay | 0.75 | corn |
| Dennis Bennett | Morley clay loam | 3.99 | soybeans |

No further treatment was applied prior to applying simulated rainfall tests in the late spring of 1974. These treatments represented conditions that would occur in late winter and early spring after the soil had gone through the winter's weathering process (freezing and thawing, wetting and drying, rain and snow periods). Based on past erosion tests this should be the most critical erosion period for fall plow, fall chisel, and even the check treatment. On the other hand the disk treatment might be less susceptible at this time than earlier in the season.

The reasoning is as follows:

*Check* — Some residues have decomposed and washed or blown away leaving less of the soil surface protected.

*Fall plow and fall chisel* — Weathering has reduced the roughness (cloddiness) and as a result, less surface storage exists resulting in more runoff. In the case of fall chisel some of the surface residues have disappeared as well.

*Disk* — Soil material loosened by the fall disk operation has already been carried away by runoff and wind leaving more of the residue on the surface than immediately after tillage, thus providing increased protection.

These treatments were tested using simulated rainfall during late spring, 1974. Test plots were each 6 feet wide by 35 feet long. Tillage and row direction (where applicable were paralled to the predominant slope. The test storm sequence was as follows:

*Initial run* — 60 minute application at two and one-half inches per hour.

*Wet run* — 30 minute application at two and one-half inches per hour twenty four hours following the initial run.

*Very wet run* — 30 minute application at two and one-half inches per hour fifteen minutes after the end of the wet run.

Prior to rainfall, application soil moisture samples were taken. One hundred fifty pounds of nitrogen as urea with ammonium sulfate and 50 pounds of phosphorus as 0-46-0 were broadcast on one replication of all treatments shortly before the initial run. The amount of nitrogen and phosphorus that appeared in the runoff from these plots will be reported. Prior to the tests, surface residue cover was determined photographically. Runoff rates and amounts were determined by stage recorders and one percent aliquot samples of runoff were taken for sediment and nutrient analyses.

## 2. RESULTS

Photographically determined estimates of surface residue cover are shown in table 3.2.

[1]Cover estimates are averages of 6 determinations.

[2]The Morley soil had soybean residues — the other 3 locations had corn residues.

Figures 3.1 and 3.2 show the appearance of corn and soybean residues over a range of surface cover. Results from the initial, wet, very wet and three-storm totals for the four locations are given in table 3.3, 3.4, 3.5, and 3.6. Included is information on runoff, infiltration, soil concentration, and soil loss. Table 3.7 shows only a soil loss summary for the four locations.

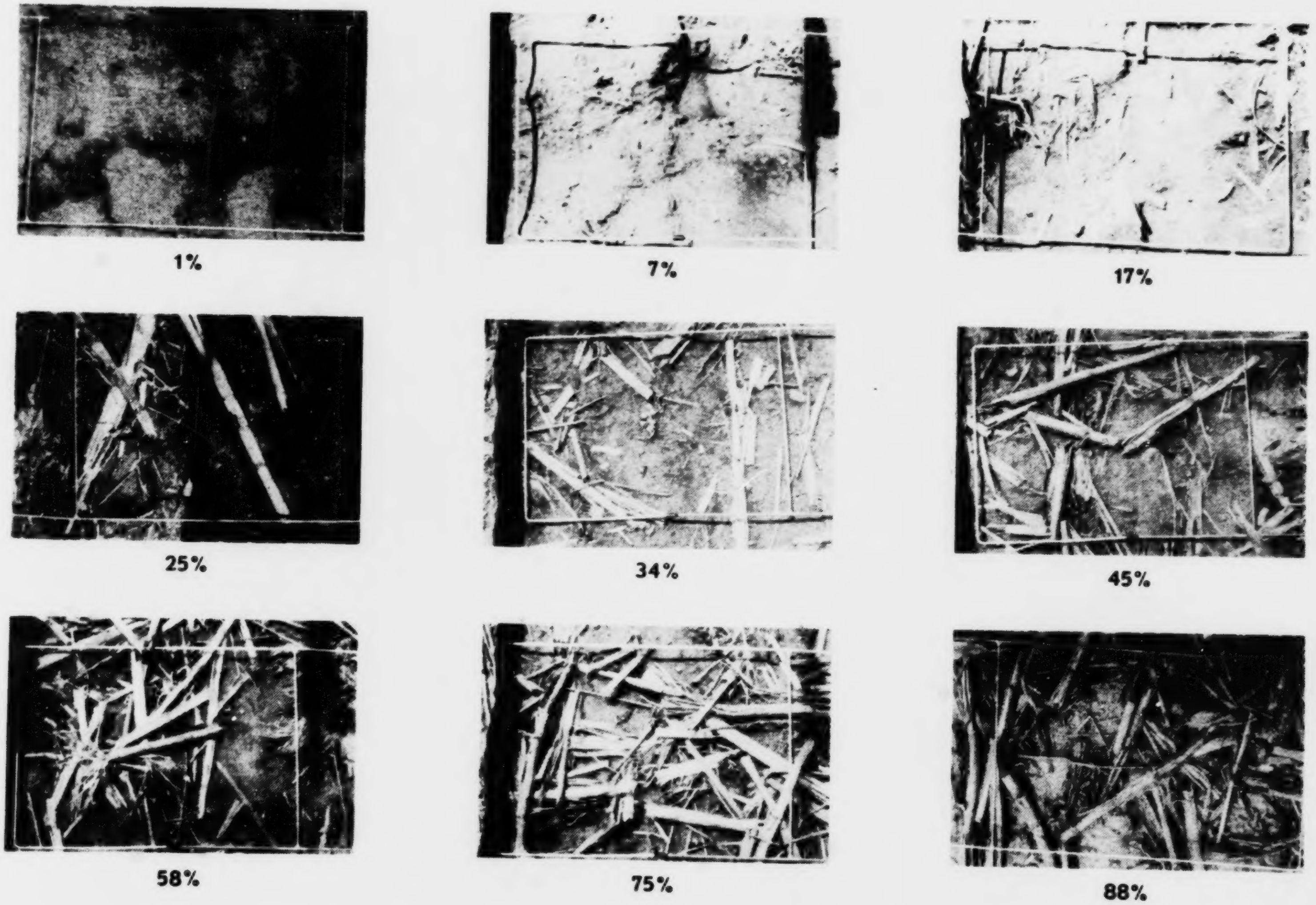
**Table 3.2 Percent Surface Cover Following Treatments**

| TREATMENT | HASKINS L. | NAPPANEE C.L. | HOYTVILLE Si.C. | MORLEY C.L. |
|---|---|---|---|---|
| Check | 57 | 53 | 78 | 26 |
| Disk | 55 | 58 | 77 | 17 |
| Chisel | 36 | 29 | 57 | 12 |
| Plow | 1 | 5 | 4 | 1 |

## 3. DISCUSSION

Appreciable soil losses occurred on the Haskins loam (table 3.3) from both the fall chisel and fall plowed treatments. Both infiltration differences and soil concentration of the runoff were important factors in the results obtained. The appreciably larger infiltration on the check plot compared to the other three treatments is difficult to explain and may result from minor topography differences between plots rather than a result of treatment. In the comparison between infiltration amounts between fall chisel and fall plow the advantage of the chisel system could well be that the rougher surface created more surface storage, thus reducing runoff amounts particularly during the initial run. The major effects of treatment appear to show up in soil content of runoff and be closely tied to surface protected by last season's corn residues. Table 3.2 indicates that both the check and disk treatments had over 50 percent of the surface covered compared to slightly over one-third for the chisel treatment and only 1 percent for the plowed treatment.

Table 3.4 gives the same results for the Nappanee soil. Here you find little difference in infiltration resulting from treatments. However, the past season's corn residues have significant effects on soil concentration of the runoff and therefore soil loss. Percent surface cover amounting to 53, 58, 29, and 5 from the respective treatments of check, disk, chisel and plow resulted in soil losses of 0.7, 0.5, 2.1, and 3.6 tons/acre.



1%

7%

17%

25%

34%

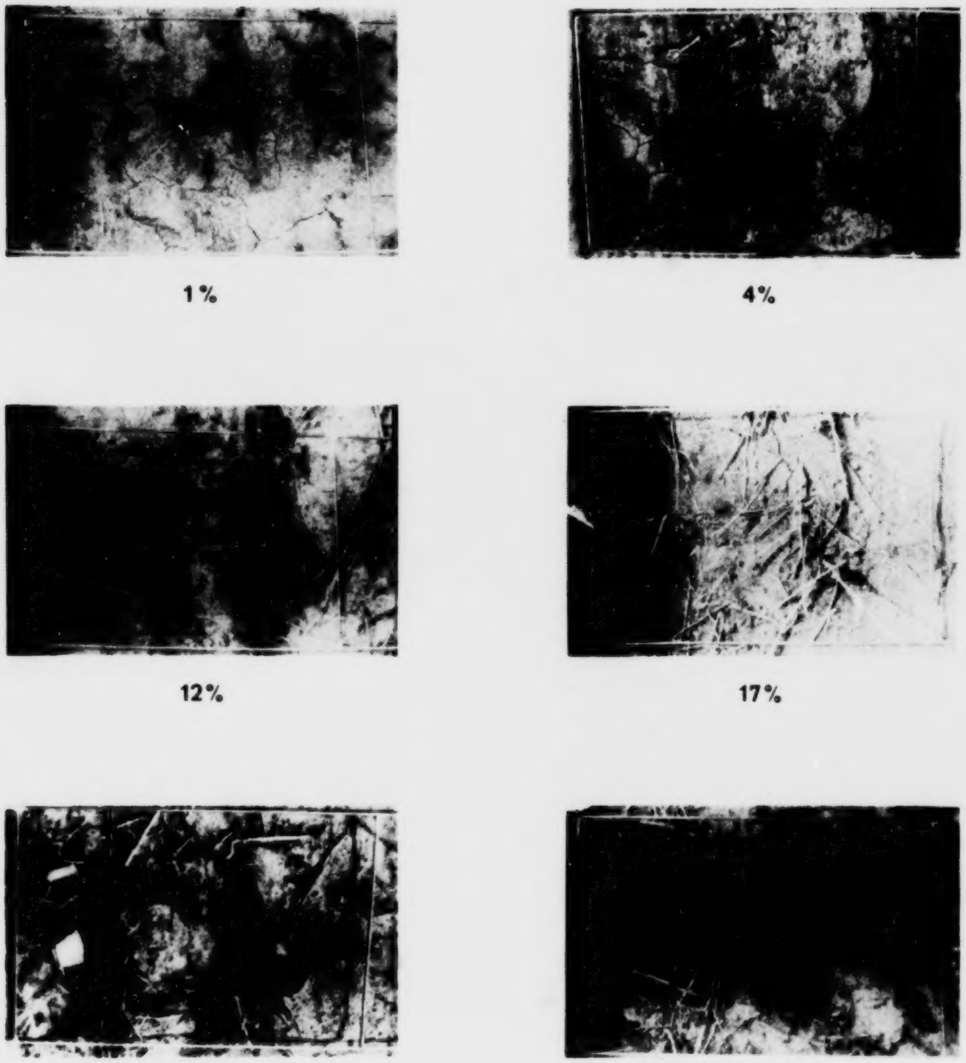
45%

58%

75%

88%

Figure 3.1 Corn Residue on Sample Plot



1%

4%

12%

17%

20%

25%

Figure 3.2 Soybean Residue on Sample Plot

**Table 3.3 Summary of Results by Test Storms, May-June, 1974, Haskins Loam**

| Treatment | Storm | Appl. (In) | Infil. (In) | Runoff 1/ (In) | Soil Cont. Runoff 2/ (%) | Soil Loss 1/ (T/A) |
|---|---|---|---|---|---|---|
| Check | Initial (60 min) | 2.50 | 1.52 | 0.98 | 1.40 | 1.43 |
| Disk | " | 2.50 | 1.22 | 1.28 | .83 | 1.09 |
| Chisel | " | 2.50 | 1.22 | 1.28 | 1.81 | 2.58 |
| Plow | " | 2.50 | .77 | 1.73 | 2.74 | 5.47 |
| Check | Wet (30 min) | 1.25 | .67 | .58 | .64 | .42 |
| Disk | " | 1.25 | .46 | .79 | .36 | .32 |
| Chisel | " | 1.25 | .28 | .97 | 1.65 | 1.79 |
| Plow | " | 1.25 | .25 | 1.00 | 2.67 | 3.04 |
| Check | Very Wet (30 min) | 1.25 | .43 | .82 | .54 | .50 |
| Disk | " | 1.25 | .14 | 1.11 | .27 | .34 |
| Chisel | " | 1.25 | .15 | 1.10 | 1.46 | 1.78 |
| Plow | " | 1.25 | .16 | 1.09 | 2.51 | 3.13 |
| Check | Total (2 hours) | 5.00 | 2.62 | 2.38 | .87 | 2.35 |
| Disk | " | 5.00 | 1.82 | 3.18 | .49 | 1.75 |
| Chisel | " | 5.00 | 1.65 | 3.35 | 1.62 | 6.15 |
| Plow | " | 5.00 | 1.18 | 3.82 | 2.69 | 11.64 |

1/ Runoff and soil loss have been adjusted to a constant intensity of 2 1/2 in/hr.

2/ Soil content of runoff is lbs. actual soil loss/lbs. actual runoff x 100.

**Table 3.4 Summary of Results by Test Storms, May-June, 1974, Nappanee Clay Loam**

| Treat- ment | Storm | Appl. (In) | Infil. (In) | Runoff 1/ (In) | Soil Cont. Runoff 2/ (%) | Soil Loss 1/ (T/A) |
|---|---|---|---|---|---|---|
| Check | Initial (60 min) | 2.50 | 1.26 | 1.24 | .28 | .40 |
| Disk | " | 2.50 | 1.32 | 1.18 | .20 | .32 |
| Chisel | " | 2.50 | 1.33 | 1.17 | .75 | .99 |
| Plow | " | 2.50 | 1.38 | 1.12 | 1.47 | 1.85 |
| Check | Wet (30 min) | 1.25 | .58 | .67 | .21 | .16 |
| Disk | " | 1.25 | .83 | .42 | .15 | .07 |
| Chisel | " | 1.25 | .54 | .71 | .62 | .48 |
| Plow | " | 1.25 | .58 | .67 | 1.00 | .77 |
| Check | Very Wet (30 min) | 1.25 | .44 | .81 | .18 | .17 |
| Disk | " | 1.25 | .52 | .73 | .11 | .09 |
| Chisel | " | 1.25 | .31 | .94 | .63 | .63 |
| Plow | " | 1.25 | .31 | .94 | .92 | .96 |
| Check | Total (2 hours) | 5.00 | 2.28 | 2.72 | .23 | .73 |
| Disk | " | 5.00 | 2.67 | 2.33 | .18 | .48 |
| Chisel | " | 5.00 | 2.18 | 2.82 | .66 | 2.10 |
| Plow | " | 5.00 | 2.27 | 2.73 | 1.16 | 3.58 |

1/ Runoff and soil loss have been adjusted to a constant intensity of 2 1/2 in/hr.

2/ Soil content of runoff is lbs. actual soil loss/lbs. actual runoff x 100.

**Table 3.5 Summary of Results by Test Storms, May-June, 1974, Hoytville Silty Clay**

| Treatment | Storm | Appl. (In) | Infil. (In) | Runoff 1/ (In) | Soil Cont. Runoff 2/ (%) | Loss 1/ (T/A) |
|---|---|---|---|---|---|---|
| Check | Initial (60 min) | 2.50 | 1.33 | 1.17 | .18 | .24 |
| Disk | " | 2.50 | 1.74 | .76 | .20 | .17 |
| Chisel | " | 2.50 | 2.01 | .49 | .49 | .27 |
| Plow | " | 2.50 | 1.32 | 1.18 | .67 | .90 |
| Check | Wet (30 min) | 1.25 | .68 | .57 | .17 | .11 |
| Disk | " | 1.25 | .82 | .43 | .29 | .14 |
| Chisel | " | 1.25 | 1.00 | .25 | .50 | .12 |
| Plow | " | 1.25 | .48 | .77 | .56 | .48 |
| Check | Very Wet (30 min) | 1.25 | .40 | .85 | .14 | .14 |
| Disk | " | 1.25 | .31 | .94 | .11 | .11 |
| Chisel | " | 1.25 | .54 | .71 | .48 | .35 |
| Plow | " | 1.25 | .37 | .88 | .55 | .54 |
| Check | Total (2 hours) | 5.00 | 2.41 | 2.59 | .17 | .49 |
| Disk | " | 5.00 | 2.87 | 2.13 | .17 | .42 |
| Chisel | " | 5.00 | 3.55 | 1.45 | .45 | .74 |
| Plow | " | 5.00 | 2.17 | 2.83 | .60 | 1.92 |

1/ Runoff and soil loss have been adjusted to a constant intensity of 2 1/2 in/hr.

2/ Soil content of runoff is lbs. actual soil loss/lbs. actual runoff x 100.

**Table 3.6 Summary of Results by Test Storms, May-June, 1974, Morley Clay Loam**

| Treatment | Storm | Appl. (In) | Infil. (In) | Runoff 1/ (In) | Soil Cont. Runoff 2/ (%) | Soil Loss 1/ (T/A) |
|---|---|---|---|---|---|---|
| Check | Initial (60 min) | 2.50 | .57 | 1.93 | 1.21 | 2.65 |
| Disk | " | 2.50 | .75 | 1.75 | 1.51 | 2.96 |
| Chisel | " | 2.50 | .75 | 1.75 | 3.61 | 7.08 |
| Plow | " | 2.50 | .59 | 1.91 | 4.57 | 9.81 |
| Check | Wet (30 min) | 1.25 | .21 | 1.04 | 1.25 | 1.50 |
| Disk | " | 1.25 | .34 | .91 | 1.21 | 1.27 |
| Chisel | " | 1.25 | .27 | .98 | 3.24 | 3.54 |
| Plow | " | 1.25 | .20 | 1.05 | 3.91 | 4.60 |
| Check | Very Wet (30 min) | 1.25 | .04 | 1.21 | 1.36 | 1.82 |
| Disk | " | 1.25 | .16 | 1.09 | 1.08 | 1.32 |
| Chisel | " | 1.25 | .16 | 1.09 | 1.08 | 1.32 |
| Plow | " | 1.25 | .25 | 1.00 | 3.48 | 3.85 |
| Check | Total (2 hours) | 5.00 | .82 | 4.18 | 1.26 | 5.97 |
| Disk | " | 5.00 | 1.25 | 3.75 | 1.31 | 5.55 |
| Chisel | " | 5.00 | 1.18 | 3.82 | 3.12 | 13.51 |
| Plow | " | 5.00 | 1.04 | 3.96 | 4.07 | 18.26 |

1/ Runoff and soil loss have been adjusted to a constant intensity of 2 1/2 in/hr.

2/ Soil content of runoff is lbs. actual soil loss/lbs. actual runoff x 100.

On the Hoytville soil (table 3.5) infiltration amounts were highly variable again illustrating the major effects of topographic variability between plots on runoff amounts on these nearly level areas. However, there did appear to be some advantage of the chisel treatment in surface storage. The major effects of treatment were again tied closely to residue cover. Corn residues covered 78 percent, 77 percent, 57 percent and 4 percent of the soil surface, respectively on the check, disk, chisel and plowed plots. Resultant soil losses were 0.5, 0.4, 0.7, and 1.9 tons per acre, respectively.

Two factors predominate on the Morley soil (table 3.6). First and most significant is the percent slope of almost 4 percent compared to less than 2 percent on all other locations. Runoff is greatly increased compared to the other 3 locations. Secondly, these tests were made on soybean land where much less residue was present than on corn land. Table 3.2 shows surface protection to be 26 percent, 17 percent, 12 percent, and 1 percent respectively for the check, disk, chisel, and plow treatment. (Compare these values with those on corn land.) These residues, although less than for cornland, were still a factor in reducing soil content of the runoff. Compare, particularly the differences in soil content and soil loss between the checks and disk treatment verses the chisel and plow treatments.

Table 3.7 shows major differences in soil loss to occur between locations. The effect of slope on total erosion remains a dominant factor. A soil loss of greater than 18 tons per acre occurred on the plowed Morley soil with a 4 percent slope, 11.6 tons per acre occurred on the plowed Haskins soil (1.75 percent slope) and less than 4 tons per acre occurred on plowed slopes of less than 1 percent. A comparison of the two nearly level locations (Hoytville and Nappanee) shows the better structured soil to have positive effects both in increasing infiltration and reducing soil detachment. Note particularly the plowed treatments where erosion from five inches of rain resulted in losses of 1.9 tons per acre from the Hoytville compared to 3.6 tons per acre from the Nappanee.

## 4. Conclusions and Comments

These results are of a preliminary nature and further analyses might alter them slightly. However, it can be definitely concluded that:

(1) *Type of tillage performed in the fall can have major effects on soil losses during the winter and spring months.* — Tests in late spring and early summer showed soil losses from fall chiseled land to be 53 percent, 58 percent, 37 percent, and 74 percent, respectively, of those from fall plowed land on the Haskins, Nappanee, Hoytville, and Morley soils. Soil losses from either the check or light disk treatment were 18 percent, 17 percent, 24 percent, and 32 percent, respectively of those from fall plowing on these same soils. As stated earlier, all of the treatments but the disk treatment were probably more effective in reducing soil loss earlier in the season prior to weathering and loss of surface roughness and/or loss of some of the residue from the surface. Tests made a few years ago showed fall soil losses to be greater (as much as two times) from disking than from the check (no treatment). However, at this stage of the season, fall disking appeared to be every bit as effective as the check in controlling soil losses.

(2) *Type of residue affects erosion.* — Tests indicate that the amount of residues remaining on the surface following corn is much greater than when following soybeans in late spring. (Compare figures 3.1 and 3.2 for surface cover following corn

**Table 3.7 Soil Loss in Tons/Acre Following Treatments**

| TREATMENT | HASKINS L. | NAPPANEE C.L. | HOYTVILLE Si.C. | MORLEY C.L. |
|---|---|---|---|---|
| Check | 2.4 | .7 | .5 | 6.0 |
| Disk | 1.8 | .5 | .4 | 5.6 |
| Chisel | 6.2 | 2.1 | .7 | 12.5 |
| Plow | 11.6 | 3.6 | 1.9 | 18.3 |

and beans). Soybean land also appears to be more easily eroded than corn land since the soil is normally more easily detached and transported in the runoff. More evidence is being collected in 1975 to further support this conclusion.

Laboratory work continues on relating particle size distribution of soil in place to that in the runoff sediment. The work should be ready to summarize this fall. Likewise the relation of fertilizer materials in runoff to soils and tillage treatment is still under analyses and should be ready for reporting in a few months.

# *Chisel Plowing Yields are Acceptable*

**SECTION 4**
Tillage Management Demonstrations in Black Creek

By
Donald R. Griffith and
Harry M. Galloway

Sites for demonstration of conservation tillage techniques were chosen late in 1973, and tillage systems were implemented for the 1974 crop year. The main objective of the tillage demonstrations is to acquaint cooperators and their neighbors with techniques and management practices necessary for the agronomic success of proven conservation tillage practices.

All demonstration plots were for corn following corn the previous year. The following tables include farm owners, soil types, tillage systems, populations, and yields for the 1974 demonstrations. Data are an average of 8 1/1000-acre checks per plot.

The 1974 growing season was unusual throughout — with excess rain in the spring, a severe summer drouth, and an early September frost. As a result, yields in the demonstrations were much lower than normal. Plant stress from conditions such as these tends to amplify differences in plant growth and yield caused by minor soil variations. For this reason, yield information from 1974 may be of little value in predicting corn response to different tillage methods in more normal seasons.

Fall chiseling produced corn yields equal to or better than plowing in all trials except those on the Juanita Lake farm. On this Nappanee silt loam, fall plowing had 2,000 more plants per acre and higher yield. Chiseling appears to be on the increase in the area and offers all but Amish farmers a soil conserving system adapted for widespread use in basic land preparation.

Shallow tillage with a disc or field cultivator produced yields comparable with chiseling or plowing on Rensselaer, Whitaker, Morley, and Blount soils, but yields were reduced on Nappanee.

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On the two farms where no-til was included, yields were acceptable on Blount and Whitaker soils but were reduced on Morley, due to poor weed control, and on Rensselaer, where growth was delayed due to cool wet soil. On Oshtemo loamy fine sand, variation within the trial was great, but no-til had no apparent yield advantage in a drouthy situation where surface residue should have been a positive factor.

A fifth demonstration farm, including Nappanee silt loam and Hoytville silty clay loam, has been added for the 1975 season.

**Table 4.1 Yields for Various Treatments on the Ben Eicher Farm**

| | Morley si. l | | Blount si. l | |
|---|---|---|---|---|
| Tillage | Pop. | Bu/Ac | Pop. | Bu/Ac |
| Spring plow, disc | 10,600 | 31 | 12,500 | 49 |
| Fall plow, disc | 11,200 | 34 | 11,400 | 44 |
| Disc twice spring | 13,000 | 35 | 11,500 | 40 |
| Strip tillage b/ | 12,500 | 19 | 9,300 | 43 |

a/ This is an Amish farm, and both tillage and planting were with horse-drawn equipment.

b/ A sweep was mounted ahead of each planter unit to remove trash ahead of planting. Without a coulter ahead of the sweep, stalks tended to catch on the sweep.

### Table 4.2 Yields for Various Treatments on the Roger Ehle Farm

| Tillage | Oshtemo l f.s. |  | Whitaker l |  | Rensselaer c.l |  |
|---|---|---|---|---|---|---|
|  | Pop.b/ | Bu/Ac | Pop.b/ | Bu/Ac | Pop.b/ | Bu/Ac |
| Spring plow, disc | 34,200 | 21 | 31,800 | 72 | 25,800 | 168 |
| Fall plow, disc | 34,000 | 64 | 34,000 | 80 | 28,800 | 118 |
| Fall chisel, disc | 31,800 | 54 | 31,200 | 111 | 29,000 | 184 |
| Disc once spring | 29,800 | 38 | 24,600 | 84 | 28,200 | 176 |
| Disc twice spring | 33,000 | 30 | 29,000 | 94 | 26,400 | 187 |
| No-til a/ | 29,000 | 27 | 30,000 | 81 | 28,600 | 128 |

a/ Non-powered fluted coulters were mounted ahead of each unit. There was no other tillage.
planter

b/ Stands are unintentionally high, probably due to a seed size to planter size.
mismatch of

### Table 4.3 Yields for Various Treatments on the Dick and Bruce Yerks Farm

| Tillage | Whitaker l |  | Rensselaer c. l |  |
|---|---|---|---|---|
|  | Pop. | Bu/Ac | Pop. | Bu/Ac |
| Spring plow, field cultivate 2 | 23,600 | 91 | 24,400 | 80 |
| Fall plow, field cultivate 2 | 23,600 | 84 | 23,200 | 81 |
| Fall chisel, field cultivate 2 | 24,600 | 101 | 24,200 | 77 |
| Disc twice spring | 23,600 | 104 | 23,000 | 82 |

### Table 4.4 Yields for Various Treatments on the Juanita Lake Farm

| Tillage | Nappanee si. l | | Hoytville si. c. l |
|---|---|---|---|
| | Pop. | Bu/Ac | |
| Spring plow, disc, f. cultivate | 8,000a/ | 53 | (population too erratic for accurate data) |
| Fall plow, disc, f. cultivate | 20,200 | 73 | |
| Fall chisel, disc, f. cultivate | 19,600 | 57 | |
| Disc fall and spring | 17,000 | 48 | |
| Field cultivate spring | 15,400 | 35 | |
| Disc twice spring | 17,400 | 42 | |

a/ Very rough seedbed due to wetness at plowing.

# *Stone Mulch Superior for Erosion Control*

**SECTION 5**
Ditch Bank, Slope, Mulch Studies, in Black Creek

By
Dr. Rolland Z. Wheaton

Two study areas were selected to determine the effect of slope and mulching materials on the revegetation of the stream banks and of the effects of the mulching materials in controlling erosion during the revegetation. Site 1 on the upper end of the Dreisbach Drain (on the Joe Graber farm) was installed in September-October, 1973. Site 2 on the Wertz Drain between Notestine Road and Black Creek (on the Dick Yerks farm) was installed in April, 1974. Three slopes, 2:1, 3:1, and 4:1 were used at each site. Mulch materials of stone, straw, and wood chips along with a check or no-mulch were used on both locations. In addition, aquatain and sawdust were used on the Joe Graber farm.

Results of the evaluations of the grass cover and its erosion control are reported in tables 5.1 and 5.2. The May, 1975, evaluation completed this study schedule. However, considerable channel erosion has been observed on the Graber farm with some evidence of channel erosion starting on the Wertz Drain, therefore, this will be kept under observation to see if channel scour is going to develop into a serious problem.

Data from the evaluation on May 2, 1975, show that all mulches were effective in controlling erosion and in establishing grass cover as opposed to a no mulch condition. There is no consistent difference in the mulch materials effectiveness with the possible exception of the stone mulch. It appeared to be slightly superior in controlling erosion resulting from high water and it resulted in as good or better grass cover than the other mulch materials. In May of 1974 both the wood chip and straw mulch materials were washed away during high water flow in the Wertz Drain. While there is not a total consistent advantage of one mulch material over the other, there is a very distinct advantage to using mulch material in the early establishment of the grass and of the controlling of the erosion during the establishment.

## Table 5.1 Dreisbach Drain, Graber Farm

| Mulch | Slope | 12-12-73 |  | 4-2-74 |  | 5-28-74 |  | 5-2-75 |  |
|---|---|---|---|---|---|---|---|---|---|
|  |  | E.C. | Cover | E.C. | Cover | E.C. | Cover | E.C. | Cover |
| Stone | 2:1 | G | P | G | G | G | VG | F | G |
| Straw |  | G | G | F | F | F | VG | F | G |
| Wood Chip |  | - | - | F | G | F | F | F | G |
| Saw Dust |  | G | P | F | P | F | F | F | G |
| Aquatain |  | G | G | F | P | F | F | F | G |
| None |  | G | P | F | P | F | F | F | G |
| Stone | 3:1 | G | G | G | G | G | F | VG | VG |
| Straw |  | G | P | G | G | G | F | G | G |
| Wood Chip |  | G | P | G | G | G | G | G | G |
| Saw Dust |  | - | - | G | F | G | F | G | G |
| Aquatain |  | G | VG | G | G | G | F | G | G |
| None |  | G | G | G | F | G | FG | G | G |
|  |  |  |  |  |  |  |  | 2,3 | 2 |
| Stone | 4:1 | G | G | G | VG | G | VG | F | F |
| Straw |  | G | P | F | G | G | F | FG | F |
| Wood Chip |  | G | F | F | G | G | FG | F | F |
| Saw Dust |  | G | P | F | G | G | F | F | F |
| Aquatain |  | FG | F | F | F | G | F | F | F |
| None |  | F | P | F | P | G | F | F | F |

P = Poor
F = Fair
G = Good
VG = Very Good
EC = Erosion Control

1. Original application to light - second opperation necessary
2. 2:1 and 4:1 plots low in fertility especially in May 1975
3. Erosion at toe of slope not necessarily related to mulch material

## Table 5.2 Wertz Drain, South of Notestine Road

| Mulch | Slope | 5-14-74 |  | 5-28-74 |  | 5-2-75 |  |
|---|---|---|---|---|---|---|---|
|  |  | E.C. | Cover | E.C. | Cover | E.C. | Cover |
| Stone | 2:1 | G | none | G | F | VG | VG |
| Straw | 2:1 | G | none | G | G | VG | VG |
| Wood Chip | 2:1 | G | none | G | G | VG | VG |
| None | 2:1 | G | none | G | F | G | G |
| Stone | 3:1 | G | none | G | F | VG | G |
| Straw | 3:1 | G | none | G | G | VG | G |
| Wood Chip | 3:1 | G | none | G | F | FG | FG |
| None | 3:1 | G | none | G | F | G | F |
| Stone | 4:1 | G | none | G | P | VG | VG |
| Straw | 4:1 | G | none | G | G | VG | VG |
| Wood Chip | 4:1 | G | none | G | P | VG | VG |
| None | 4:1 | G | none | G | P | VG | VG |

P = Poor
F = Fair
G = Good
VG = Very Good
EC = Erosion Control

All but stone mulch washed away in high water first week of May 1974. Sediment up to 2" thick deposited in 4:1 slope plots during this high water. Less sediment in 3:1 and 2:1 plots.

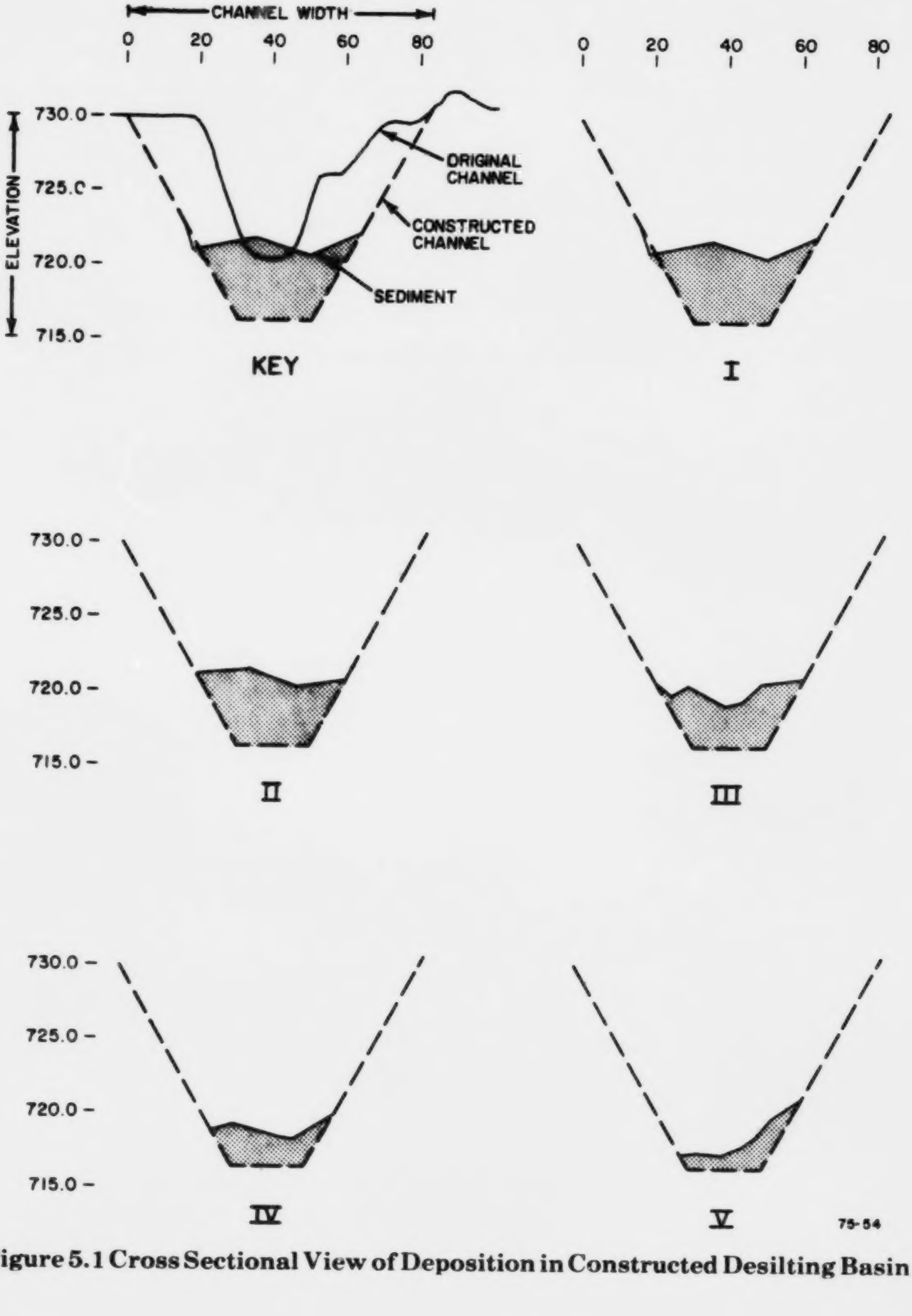

CHANNEL WIDTH
0
20
40
60
80
730.0
725.0
720.0
715.0
ELEVATION
ORIGINAL CHANNEL
CONSTRUCTED CHANNEL
SEDIMENT
KEY
I
II
III
IV
V
75-54

Figure 5.1 Cross Sectional View of Deposition in Constructed Desilting Basin

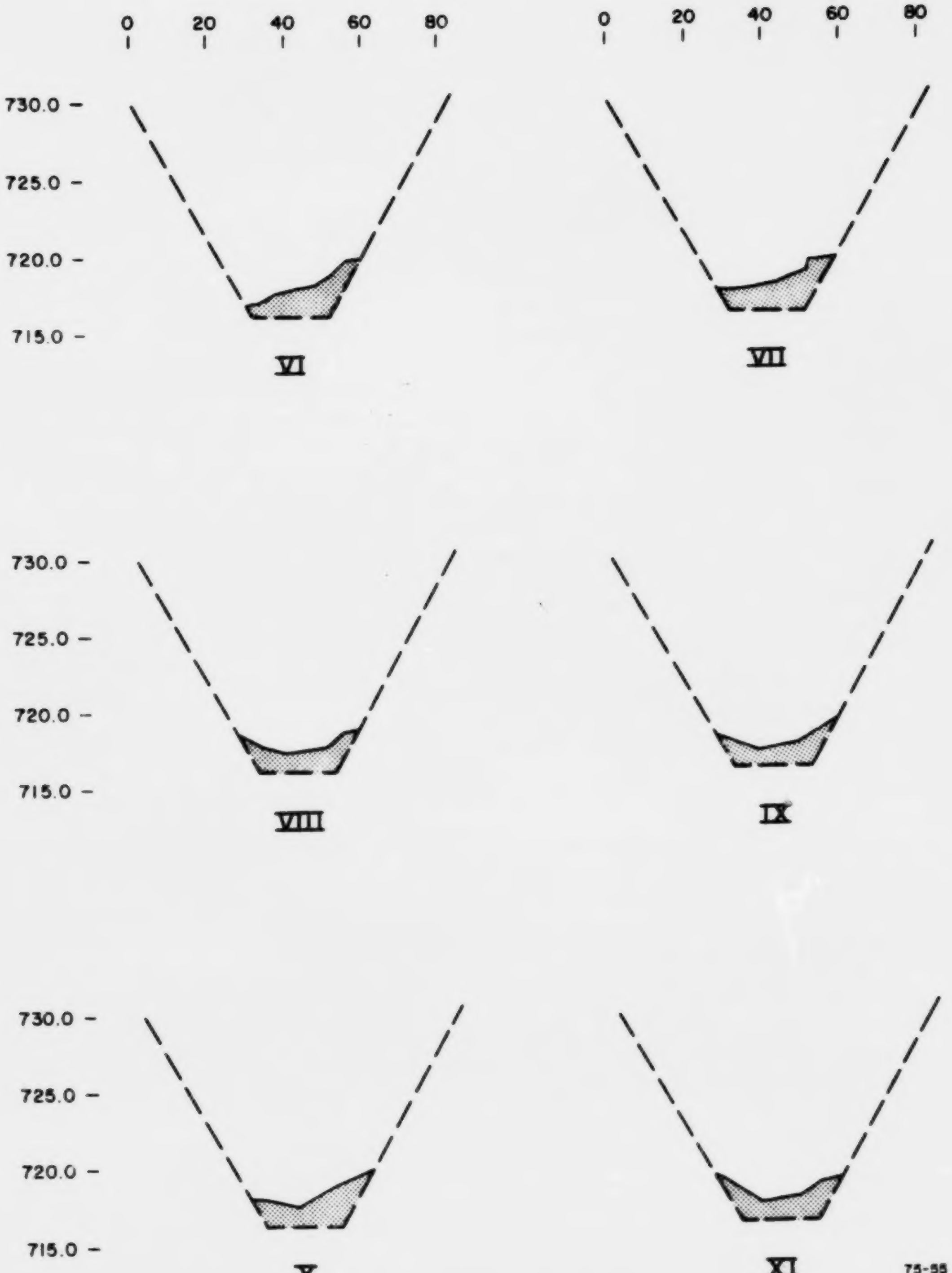


Figure 5.2 Cross Sectional View of Deposition in Constructed Desilting Basin

The 3:1 slopes appear to be slightly better than either the 2:1 or the 4:1 slopes. However, this can vary with local conditions. For example, on the Graber farm the 3:1 slopes are far superior to the others but this is complicated by the fact that there was more good soil on the 3:1 slopes than on any of the other two slopes which had been badly eroded before revegetation. In fact, a year and a half after the establishment and planting of the grass, the 2:1 and 4:1 slopes on the Graber farm still show evidences of low fertility.

Since the evaluation on May 2, 1975, several major flows have occurred in these two channels. At least one of the storms was of 100-year or greater frequency. These sites will be re-evaluated to determine the effects of the storm flows in May and June of 1975 although initial evidence following the May storm indicated that the vegetation had protected the banks from serious problems.

Three sites were initially selected for studies to determine if the channels are agrading or degrading. Two of the sites have since been reconstructed and revegetated. The evaluations were made on the third site in 1974, however, in the spring of 1975 it was found that someone had removed the stakes. Nevertheless, observation of the site (Wertz Drain south of the woods and north of Antwerp Road) indicates that the channel is relatively stable with little or no accumulation or loss.

In the first annual report it was mentioned that high water flow during May of 1974 deposited one to two inches of silt and sand on the mulch study plots on the Wertz Drain. Other evidences of such deposition during high flows has been observed throughout the watershed. There is also evidence of continued cutting of some of the channels where velocities of flow are high. This seems to be especially true where velocities are high during normal to low flow such as occurs on the mulch study area on the Dreisbach Drain. Observations of channel scour are in agreement with stability studies conducted by Doug West which showed that many of the lower bank and channel bottoms were unstable for existing flow and slope conditions throughout many areas of the basin. The two mulch study sites as well as others will remain under observation for evidences of channel cutting.

Staff of the Soil Conservation Service have been evaluating stream bank erosions for the United States part of the International Joint Commission program. Black Creek was selected as one of the detail studies. This work on Black Creek started in April and May, 1975. Preliminary work indicated that the channel erosion throughout the area is relatively small.

A desilting basin on the Kenneth Hirsch farm located on the main stem of Black Creek was constructed in the fall of 1974. The amount of sediment was to have been surveyed in the early spring of 1975, but heavy rains which continued into June made a detailed survey impossible. A survey was finally prepared on July 30, 1975. Although this is outside the period covered by this report, the results are presented here.

Visual inspection during the spring of 1975 indicated that the basin was filling. It was estimated that perhaps the first 25 feet of the basin was filled with silt by late April of 1975 and that the first 75 feet had been filled by June.

Results of the July 30 survey are presented in figures 5.1 and 5.2. The figures provide a key indicating the original channel cross section, the cross section of the reconstructed basin, and the profile of sediment contained in the basin at the date of the survey. The original basin was constructed over 540 feet of the Black Creek with 400 feet at the full basin width. Taper back to the regular channel was provided both upstream and downstream of the main basin which was constructed with a top width of 80 feet, a bottom width of 20 feet and with side slopes of 2.5:1.

The profiles in figures 5.1 and 5.2 are identified according to the notation of the Allen County Surveyors Office. The entrance to the basin is at station 456+30 with indicates 456 x 100 + 30 feet or 45630 feet downstream of the source of the Black Creek.

As indicated in figures 5.1 and 5.2, at station 457+00, the sediment storage is completely full with more than five feet of collected material. At this station there is a small channel for low flow near the right bank (looking downstream). Similar conditions exist at station 457+40. At station 457+50, the low flow has shifted to the center and the sediment storage area is at least 75 percent full. From station 458+00 to the outlet, approximately one foot of material has been collected.

In the 10 months that passed between completion of construction and the survey, 980 cubic yards of silt, sand, and fine gravel were trapped in the basin. Preliminary sampling of the collected material indicates that the last 300 feet is of silt-size particles. The top material for the first 100 to 150 feet is of the sand and fine gravel size. Particle size versus depth for the upper reaches of the basin have not been determined so an estimate of the volume of various particle sizes trapped cannot be made at this time.

Two significant factors must be considered when reporting the 980 cubic yards of material trapped in the ten-month period.

(1) a very intense rain storm occurred on May 20, 1975. This storm has a return frequency of over 100 years. It produced runoff over bank full for several hours. See the following section for some of the observed effects of this storm.

(2) during the late summer and fall of 1974 considerable sloping and revegetation of ditch banks occurred upstream of the basin. In several instances the vegetation was slow in becoming established. It cannot be determined what the effects of the streambank stabilization work may have had on the amount of material trapped by the desilting basin.

Present plans call for a resurvey of the basin at least on an annual basis. A more frequent survey will be conducted if major runoff events occur.

Nearly four inches of rainfall were received throughout the Black Creek Watershed between 3:00 and 5:30 a.m., May 20, 1975. Examination of the rainfall records indicate that the storm was unusual in two aspects.

(1) It was unusually uniform over the watershed for such an intense storm, and

(2) It was very uniform in intensity throughout the storm period.

Detail analysis have not been completed but the storm was at least of a 100-year return frequency. It produced general flooding throughout the area, ditch bank full flows, and considerable erosion.

Several Purdue staff members were working in the field the days before and after this storm occurred, so many significant observations and measurements were made. Some of these will be included in other sections of this annual report.

The following general comments can be made concerning erosion from the May 20 storm:

(1) Finely prepared seed beds increased both erosion and compaction problems.

(2) Tillage systems that leave residue on the surface and/or the surface rougher and cloddier fared better than finely tilled fall plowed seed beds.

(3) The residual effects of sod crops in reducing the erosion potential of plowed land was evident in the northern part of the watershed.

(4) More grass waterways are needed to prevent scouring where water tends to channel during excessive storms.

(5) There are some critical areas (even in the southern part of the watershed) that should be returned to permanent vegetation.

In reviewing the effects of this storm, the infrequent nature must be recognized. While considerable damage and erosion did occur, it is not practical to expect to control all the damage or even to prevent flooding from such an infrequent event. Nevertheless, the unusual nature of this storm does point out the need for increased erosion protection.

# *Stream Basin and Terrestrial Environment Factors in Fish Community Structure*

By
**James R. Karr**

## 1. IMPACT OF CHANNEL MODIFICATION

In a previous report, we noted three variables of primary importance in causing changes in fish species diversity within Black Creek, although much of our evidence at that time was anecdotal. These variables are season, degree of bank reconstruction, and nature of terrestial environment in the immediate vicinity of the stream.

Recognition of the significance of seasonal fish movements into Black Creek from the Maumee was an early conclusion of our field studies. Last year we showed that massive migrations by several species occur during the spring spawning season. Since then, we have documented a large scale migration by several species, especially spotfin shiner, in August and September. Evidence for this spotfin migration is given in figure 6.1. Note that small numbers of relatively small fish are captured in the spring, while many larger fish are caught in the fall. By winter, large numbers of young of the year are caught; but all large spawners have departed. Since Black Creek is larger below Ward Road, resident populations of spotfin shiner are able to maintain themselves throughout the year. Presumably the fish spawning in the upper reaches of Black Creek and its tributaries come from this population and the Maumee River. Other species for which there is evidence of a fall migration include gizzard shad and quillback carpsucker.

Our research plan for this spring included extensive studies of the dynamics of these seasonal movements. However, severe alterations or habitat destruction have caused a sharp decline in numbers of fish species and individuals in the Black

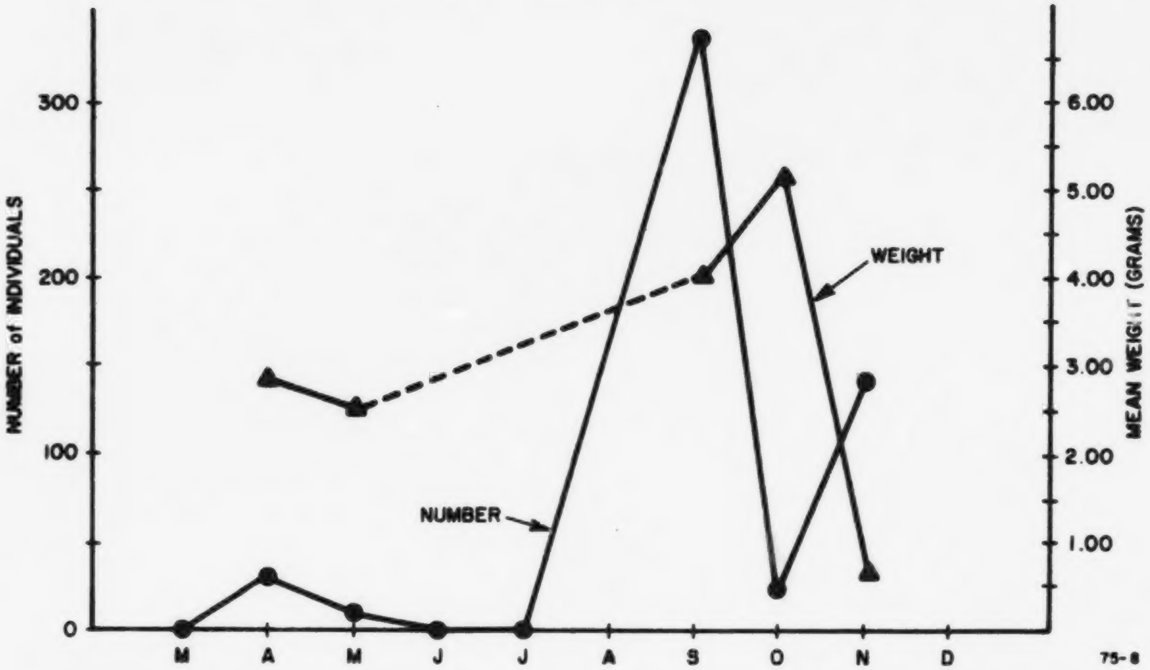
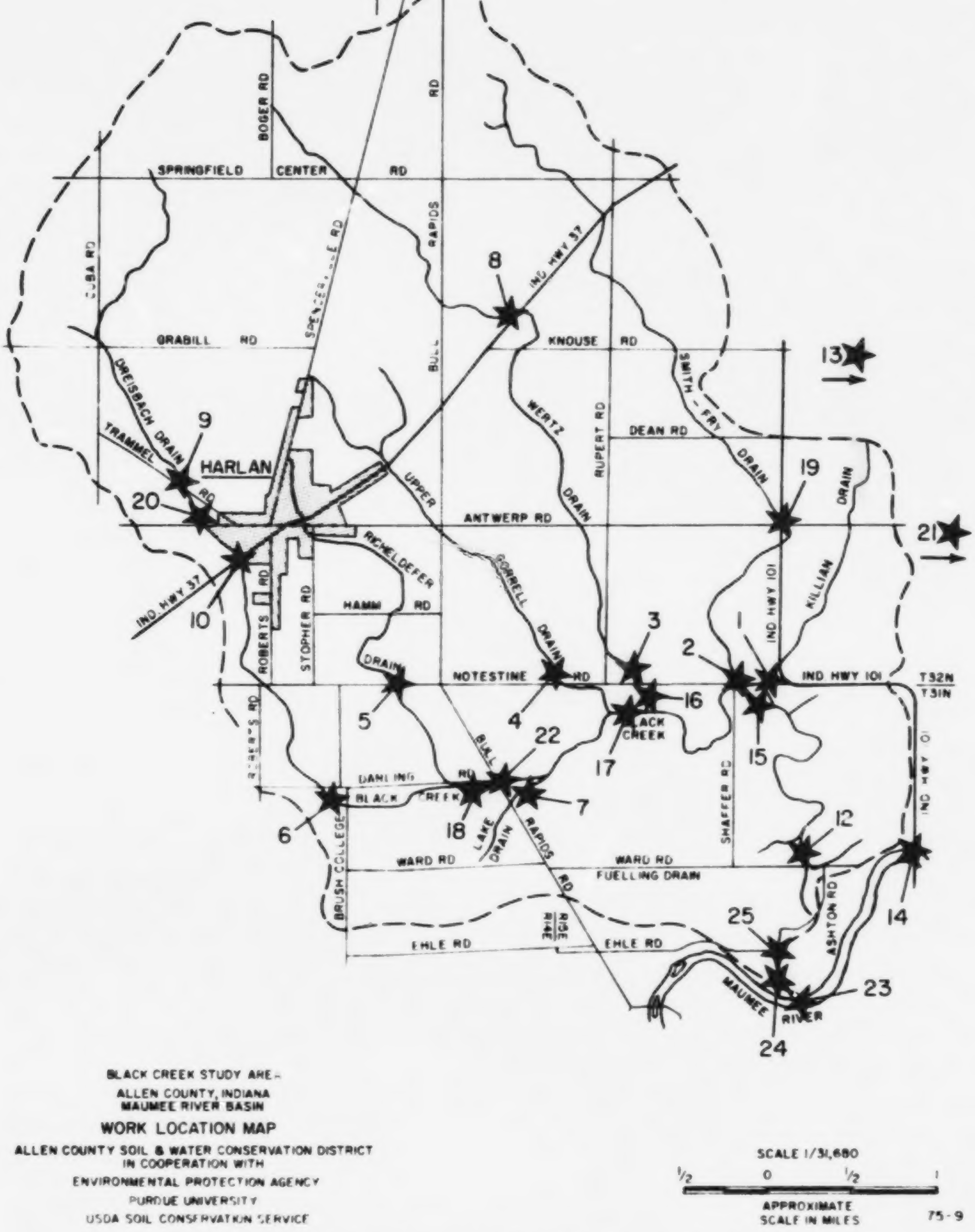


Figure 6.1 Seasonal Changes in Abundance and Mean Weight, Spotfin Shiner from March to November, 1974. (Black Creek Station 12)

Table 6.1 Capture of Fish at Black Creek Station 15, Spring, 1974 and 1975

| Date | Number of fish per meter of stream | Mean weight (gms.) |
|---|---|---|
| 12 April 1974 | 4.20 | 25.85 |
| 20 May 1974 | 1.00 | 12.71 |
| 22 March 1975 | 1.14 | 3.38 |
| 5 April 1975 | 1.58 | 1.56 |
| 19 April 1975 | 2.74 | 3.33 |
| 3 May 1975 | 0.99 | 2.03 |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KILLIAN DRAIN
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BLACK CREEK STUDY AREA
ALLEN COUNTY, INDIANA
MAUMEE RIVER BASIN
WORK LOCATION MAP
ALLEN COUNTY SOIL & WATER CONSERVATION DISTRICT
IN COOPERATION WITH
ENVIRONMENTAL PROTECTION AGENCY
PURDUE UNIVERSITY
USDA SOIL CONSERVATION SERVICE
SCALE 1/31,680
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SCALE IN MILES
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Figure 6.2 Fish Sampling Stations, Black Creek

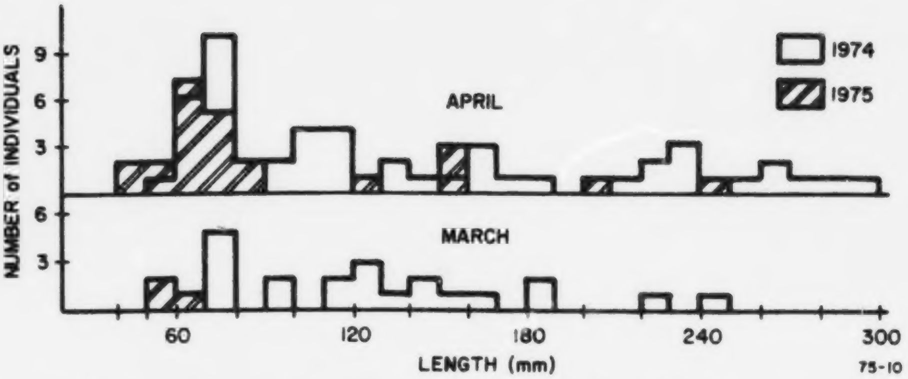


**Figure 6.3 Size-Frequency Distribution, White Sucker, March-April, 1974**

Creek area. These modifications have come in three forms: Channel modification, construction which blocked fish movements, and, apparently, herbicide use. Evidence of the effects of channel modification is typified by the situation at station 6 and station 15 (See map — figure 6.2 for location).

Table 6.1 indicates:

(1) At the peak of migration in mid-April densities are lower in 1975 than in 1974.

(2) The mean weights of fish are much lower in 1975 than in 1974 indicating that the large spawning fishes are not reaching the area.

These figures represent an overall lowering of fish densities and more importantly a reduction in numbers of large fish. Additional evidence for the suggestion of reduced populations of large fish can be seen if one compares the length distribution for white suckers captured in 1974 and 1975 (figure 6.3). This indicates that the large fish were either killed by last year's stream modifications, or have been blocked from moving upstream to spawn. Since both stream modifications and barrier construction have occurred since the spring of 1974, it is not possible to distinguish the relative effects of these two factors.

An indication of the relative effects of these two factors can be obtained by examining the capture history at station 6. Weirs with automatic water samplers were installed at several locations between February 4 and 13, 1974, including one about 40m downstream from station 6. In the spring of 1974 these weirs did not block fish migrations but following the addition of rock at weirs some structures became effective barriers to fishes. Even casual field observations reveal a concentration of fishes below weirs and a relative scarcity above weirs with quantities of rock that exceed normal water depths. Station 6 (table 6.2) exemplifies this situation.

Note that high populations and species numbers were recorded in summer, 1973 and spring, 1974 before the stream was channeled. After channelization there was a precipitous decline in fishes. The number remained low for nearly a year. Under normal circumstances we would expect an increase in the fishes, even in a channeled area, with the spring migration. However, the weir and associated rock at Brush College Road prevented such a migration until the high water following the rains in early May. The May 29 sample involved large numbers of small fish al-

**Table 6.2 Captures of Fish Following Disturbances, Black Creek Station 6**

| Date | No. Indiv. | Wt./Ind. (gms) | # Species |
|---|---|---|---|
| 24 July 1973 | 201 | 13.53 | 9 |
| February 1974 | weir installed | | |
| 5 March 1974 | 301 | 9.87 | 8 |
| 12 April 1974 | 69 | 5.70 | 7 |
| | stream channelized | | |
| 20 May 1974 | 10 | 1 | 2 |
| October 1974 | 32 | 4.5 | 3 |
| 23 March 1975 | 3 | 1.6 | 1 |
| 5 April 1975 | 0 | 0 | 0 |
| 3 May 1975 | 9 | 1.1 | 1 |
| | unusually heavy rains flood | | |
| 29 May 1975 | 174 | not weighed | 9 |

though no weight data are available because the fish were returned to the stream. Note that while fish returned to Brush College Road, the major spawning runs of early spring were past and reproduction is likely to be too late and/or well below average. Many fish attempting to get upstream to spawn now depend on major floods to allow passage over the weirs.

Another incident demonstrates the effectiveness of the weirs in blocking fish movements. In September 1974, many spotfin shiners were captured in Black Creek. Near station 18 just west of Bull Rapids Road one 50m sample netted over 100 spotfin shiners. Many spotfins were found throughout the east-west portion of Black Creek but very few were captured above the weirs on Black Creek and Smith-Fry, and Wertz Drains. The water below the bridge at Brush College Road was swarming with spotfins, for example, but none were captured 40m upstream of the weir in station 6.

The construction of a new bridge on the Black Creek at Ward Road may have been the most detrimental barrier to fish migration and reproduction in 1975. A large conduit pipe formed a sizeable waterfall and, therefore, an effective barrier to even the largest fish attempting to reach spawning areas in Black Creek and its tributaries. On April 19, 1975, we sampled the pool just below the conduit and captured many large and small fish. Six large white suckers were captured in the small pool, for example. They averaged 270mm (10.7 inches) in length. When released they continued their unsuccessful struggle to move upstream through the pipe.

All over the drainage, the combined effects of barriers and channelization were dramatic. Which is the most important is not easy to determine at this time because of the lack of controlled experiments. However, one thing is clear. If the fish cannot reach high quality spawning grounds they will not reproduce and their populations may be doomed.

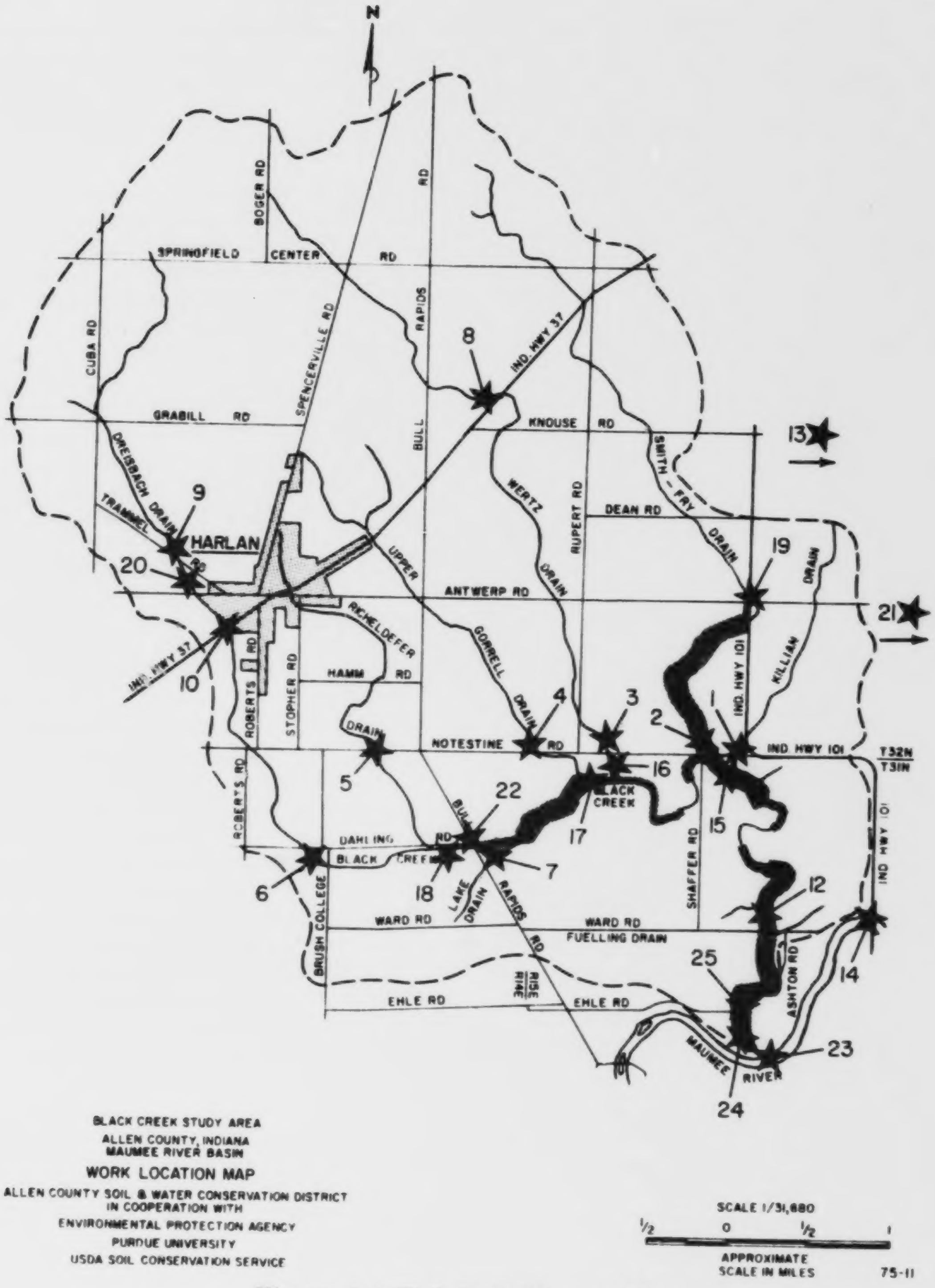
Our "control" stream, the Wann, just east of Black Creek is instructive. This stream was channelized about five years ago, but no migration barriers have been identified. Two sample stations in the Wann Drainage consistently have more species and large breeding adults during the spring migrations. Presumably following channelization, stable fauna can develop after subsequent return of banks and instream vegetation growth. The question now is how does a "healed," channelized stream compare to a natural stream?

## 2. FISH STUDIES IN "WERTZ WOODS"

The Wertz Drain flows for about 1700 feet through a small woodlot between Knouse and Antwerp Roads. We have named this "Wertz Woods." Inside the woodlot the stream meanders in a complex sequence of pools and riffles associated with erosion and deposition areas. Observations to date show that these pools and riffles house a rich and varied fish fauna, much of which seems to be resident throughout the year. During July of 1974, Owen and Wendy Gorman spent several days in intensive studies of the stream in the section of land around the woods. Outside the woods in the channelized areas of the stream, few fishes could be found in the algae choked ditches where water temperatures reached as high as 28°C (82.4°F). Inside the woodlot the deep pools contained many fish and water temperatures were much lower at 19°C (66°F). In addition no algal growth was noted. Over the past year the general structure of the stream, has remained stable by comparison to the ditches where pools may silt in rapidly (e.g. the settling basin) with heavy rainfall and whole banks may erode rapidly. Large deep pools, for example, in the forest allow fishes to survive through dry periods in August and September while nearby, channeled areas of stream are either too hot, too choked with algae or dry. Pools, then, protected from the direct rays of the sun prevent the local extinction of fish populations in sections of streams where drought conditions allow little or no net flow.

## 3. EFFECTS OF THE MAY FLOOD

In late May a major rainfall event occurred which resulted in overnight changes in the Black Creek. On May 19, we sampled a number of stations which had water depths of a few inches or less. By the next morning about four inches of rain had fallen and the streams of the Black Creek Basin were raging torrents as deep as 10 to 15 feet. We do not have any extensive data to document the effects of this flood on the fishes except that it allowed many fish to disperse upstream past the weirs. Its affect on other aspects of the fishes lives can only be guessed. Certainly the high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RUPERT RD
DEAN RD
SMITH - FRY DRAIN
ANTWERP RD
RICHELDEFER
GORRELL DRAIN
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KILLIAN DRAIN
BLACK CREEK
SHAFFER RD
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DARLING RD
BLACK CREEK
BRUSH COLLEGE
LAKE DRAIN
WARD RD
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BLACK CREEK STUDY AREA
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USDA SOIL CONSERVATION SERVICE
SCALE 1/31,680
1/2
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APPROXIMATE
SCALE IN MILES
75-11

Figure 6.4 Fish Kill, May, 1975

sediment load and erosion potential of the stream destroyed most of the nests of the fish that had already spawned. It seems likely that any benefits from increased dispersal were negated by destruction of nests or newly hatched fry.

## 4. A MAJOR FISH KILL

On May 29, several of my students were doing routine sampling in the Black Creek area when they discovered large numbers of dead fish in Smith-Fry Drain at station 2. Dead creek chubs, white sucker, bluntnose and fathead minnows, common shiner, silverjaw minnow, and rainbow darters were noted. The number of dead fish in the vicinity of station 2 numbered in the hundreds, with all sizes affected up to seven-inch creek chubs. Routine sampling at station 2 yielded only one live fish. Additional dead fish were noted at station 15 on Black Creek but none were found on Black Creek near Shaefer Road above the junction of Smith-Fry Drain and Black Creek. Thus the dead fish at station 15 were apparently from the fish kill in the Smith-Fry. In an effort to clarify the reason for the fish kill two students walked upstream along Smith-Fry Drain to determine the extent of the fish kill. They also walked most of Black Creek from Bull Rapids Road to where Black Creek enters the Maumee River. The extent of the area of fish kill is noted in figure 6.4. In addition, a dead raccoon was found in the Smith-Fry Drain below Indiana Highway 101. The following excerpts from field notes indicate the magnitude of the fish kill at several locations.

*Black Creek from Gorrell Drain to Bull Rapids Road —*

> High density of dead fish include large carp; fish thinned out above Lake Drain and none above Bull Rapids Road.

*Station 12 area at Ward Road —*

> Large numbers of dead fish were observed above and below the bridge. Estimated several thousand dead fish in 400 to 500 meters of stream above Ward Road, including 12-inch bullhead and 16-inch carp.
>
> Heavy concentration of dead fish between Ward Road and the Maumee River.

Discussions with the people from the area suggest that herbicide application had been made just prior to the fish kill. Generally, herbicides will not be toxic to fish but less than careful application along the stream banks might produce a significant fish kill. A brief discussion with the young man collecting water samples determined that he had found the stream to be foul smelling and with considerable foam on the surface on May 28. Regrettably, he did not take any water samples and my students did not collect any of the fish for pesticide analysis. A complete list of the 16 species affected by the massive fish kill is presented below:

(1) Carp
(2) Stoneroller
(3) Creek Chub
(4) Green Sunfish
(5) White Sucker
(6) Bullhead
(7) Quillback Carpsucker
(8) Blackstripe Topminnow
(9) Golden Shiner
(10) Bluntnose Minnow

(11) Fathead Minnow
(12) Common Shiner
(13) Spotfin Shiner
(14) Redfin Shiner
(15) Sand Shiner
(16) Silverjaw Minnow

The long term effect of the fish kill on our studies or on fish populations in Black Creek is impossible to determine at this time.

## 4. WATER QUALITY IN AND NEAR WERTZ WOODS

As part of our studies of the effects of Wertz Woods on Wertz Drain we have initiated a program of routine water sampling between Knouse and Antwerp Roads (figure 6.5). Samples from July, September, and October, 1974 show a clear trend for decreasing amounts of suspended solids as the stream flows through the forested portion of the stream (figure 6.6). There is a similar decline in February, 1975 but March and April samples did not have declines in sediment within the forest. The most obvious hypothesis is that with increased flow rates the effectivity of the pool and riffle nature of the stream in the forest as a natural sediment basin declines.

Flow rates on the days of water samples in 1975 were as follows:

February 8 — 2.0 cfs
March 20 — 2.2 cfs
April 19 — 1.7 cfs
May 20 — 227 cfs

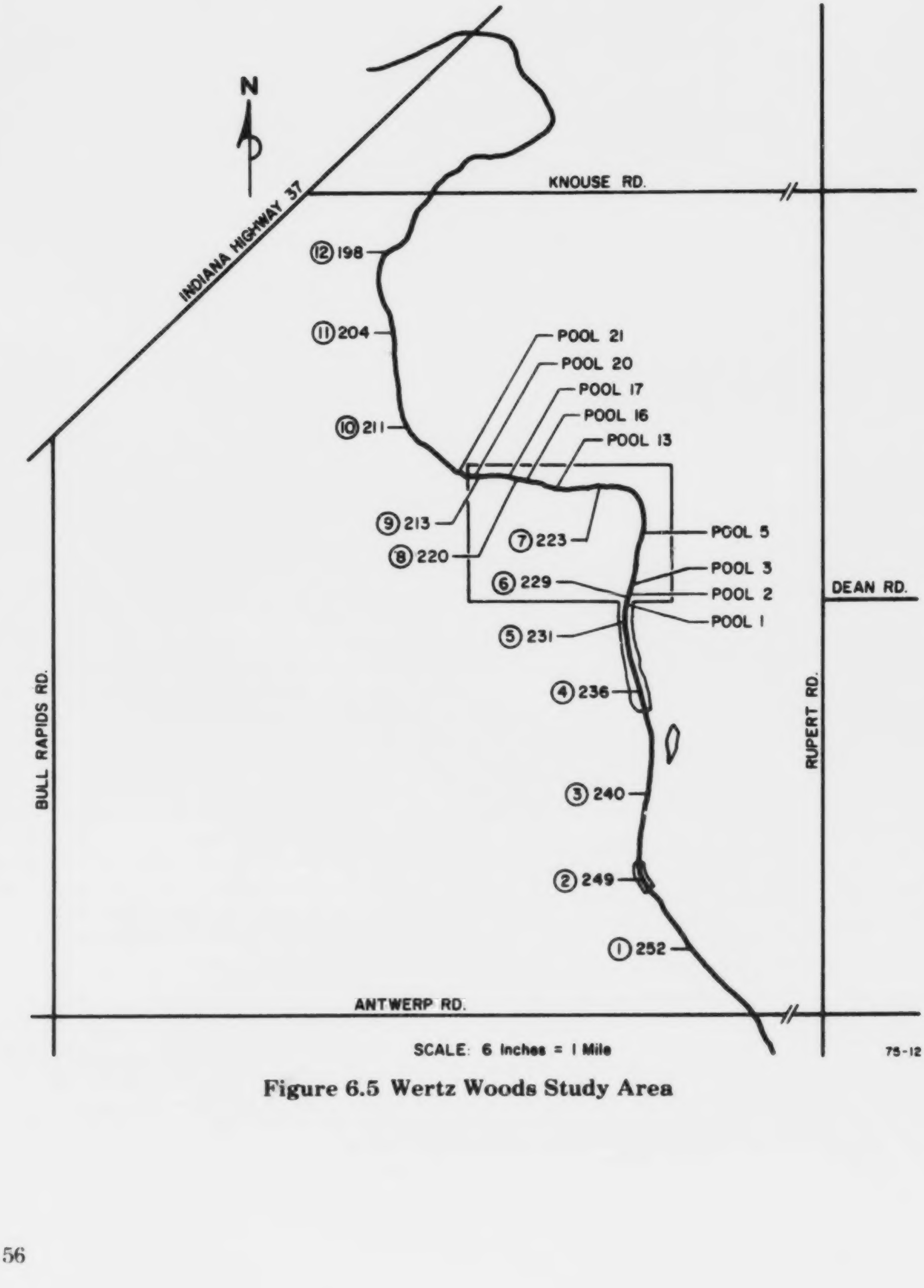
Similar data for the 1974 sample times is not yet available.

By coincidence we were doing our normal sampling on the day of the unusually large flood in late May. We made our routine water samples and several grab samples (figure 6.6). Sediment loads in the lower region of the grass waterway on Driesbach Drain were well above normal at 802 ppm. Several hundred meters downstream the sediment load had increased to 1100 ppm. We also sampled water from a drain tile at Cuba and Grabill Roads and found that the sediment load was 172 ppm. Water pouring over the drop structure at that location contained 1488 ppm of suspended solids.

Noteworthy was the continued increase in suspended solids as we moved downstream. Throughout the Wertz Drain sample area suspended solids increased with downstream movement. This was true in both agricultural and forested portions of the stream indicating that at very high flows the natural sediment basin capability of the Wertz Woods was not functional.

A grab sample at Ehle Road on Black Creek during the morning of May 20 contained an astounding sediment load of 5767 ppm (figure 6.6). From these data it is clear that both the upland rolling portion of the drainage and the flatter floodplain areas of the lower reaches of Black Creek are contributing major quantities of sediment to the flowing waters. Some patterns of variation in the origin of sediments are emerging but more refined data are needed before conclusions are drawn. Clearly, the effectiveness of the forest as a natural sediment basin varies.

Patterns related to nutrient dynamics are even more complex than suspended solid dynamics in the Wertz Woods area. In the mid-summer period we found very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POOL 21
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POOL 16
POOL 13
POOL 5
POOL 3
POOL 2
POOL 1
DEAN RD.
RUPERT RD.
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ANTWERP RD.
SCALE: 6 Inches = 1 Mile
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Figure 6.5 Wertz Woods Study Area

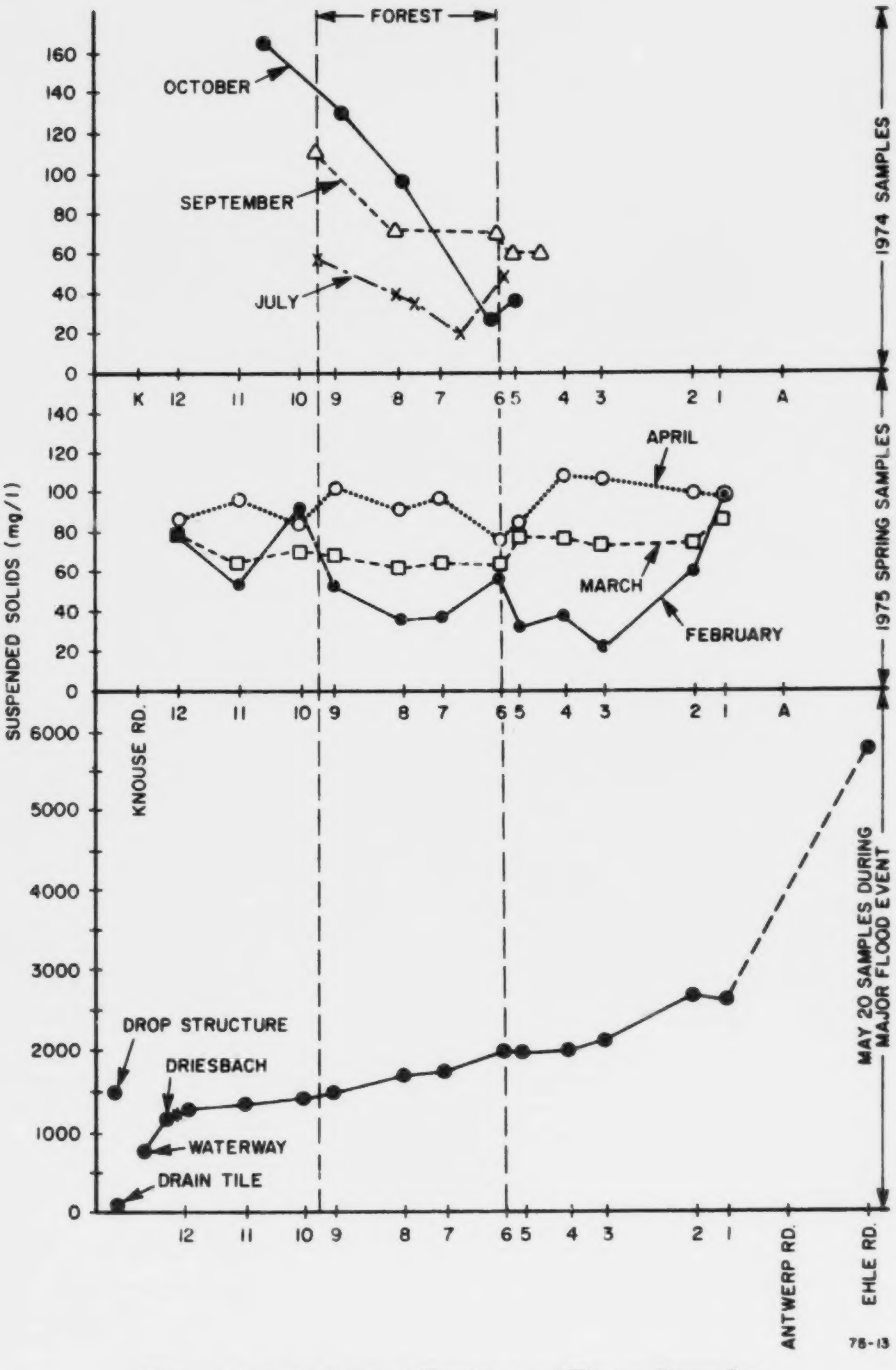

Figure 6.6 Sediment Content of Water Samples

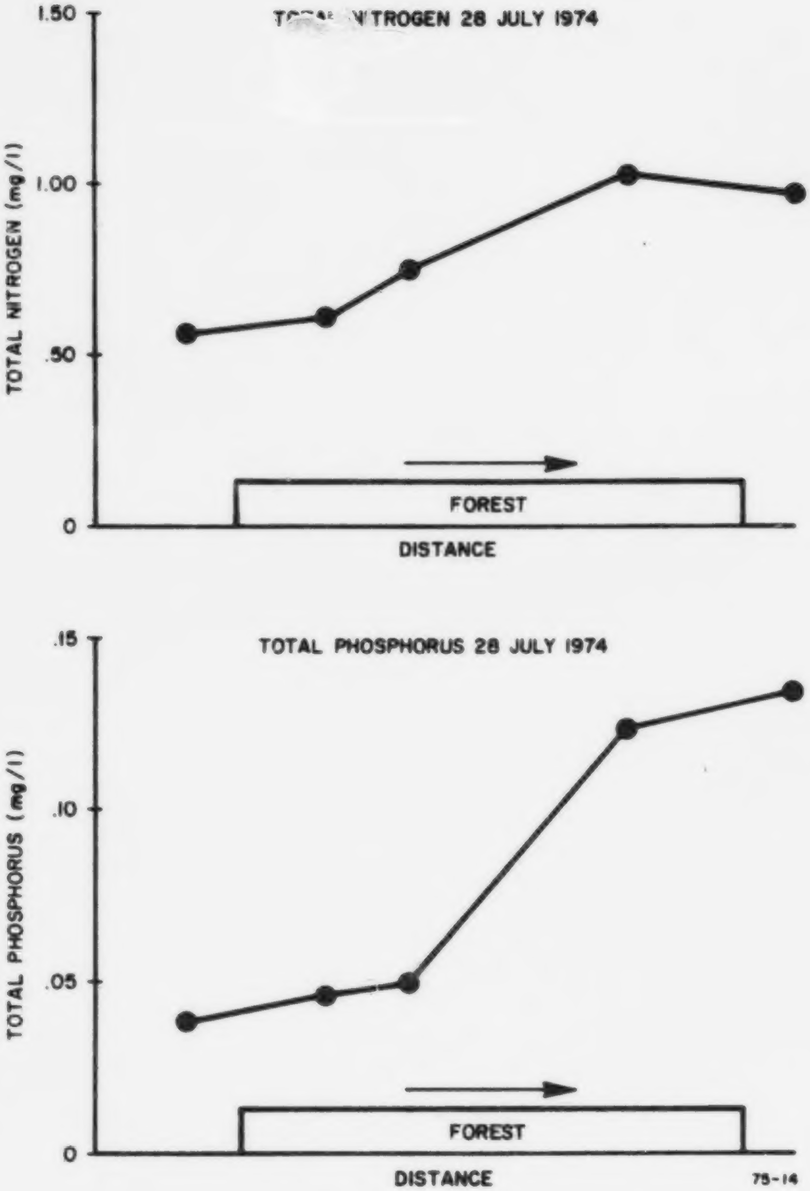

**Figure 6.7 Total Nitrogen and Phosphorus Wertz Woods Water Samples During Season of High Algal Density**

**Table 6.3 Length-Weight Regression for Fish Collected in Black Creek, Spring and Summer, 1974**

| Species | Intercept Slope | | | | R | N |
|---|---|---|---|---|---|---|
| Creek Chub | Log W = | -5.30 | +3.21 | Log L | .995 | 320 |
| Common Shiner | Log W = | -5.44 | +3.27 | Log L | .956 | 97 |
| Redfin Shiner | Log W = | -5.21 | +3.18 | Log L | .910 | 51 |
| Spotfin Shiner | Log W = | -4.74 | +2.85 | Log L | .965 | 64 |
| Silverjaw Minnow | Log W = | -4.97 | +2.97 | Log L | .944 | 159 |
| Sandshiner | Log W = | -6.15 | +3.66 | Log L | .969 | 45 |
| Stoneroller | Log W = | -5.30 | +3.21 | Log L | .975 | 30 |
| Fathead Minnow | Log W = | -4.56 | +2.81 | Log L | .737 | 14 |
| Bluntnose Minnow | Log W = | -5.11 | +3.17 | Log L | .973 | 24 |
| White Sucker | Log W = | -4.99 | +3.03 | Log L | .997 | 63 |
| Rainbow Darter | Log W = | -5.59 | +3.42 | Log L | .842 | 44 |
| Johnny Darter | Log W = | -4.73 | +2.87 | Log L | .911 | 18 |

dense algal populations in the portions of Wertz Woods that were exposed to direct sunlight. In the forest where little incoming radiation reaches the water surface, water temperatures were lower and algal blooms did not develop.

Preliminary analysis indicates that the algal bloom results in low nutrient content in the water since most nutrients are quickly incorporated into algal biomass. Nutrient levels are higher in the forest because of the lack of algal growth. This pattern is shown in figure 6.7. At other periods of the year factors responsible for changes in nutrient content of water in the Wertz Woods area are less clear.

## 5. GROWTH RATES OF BLACK CREEK FISHES

We have completed the first stage of our analysis of length-weight data for 12 of the more common fish species captured in the Black Creek Study Area. Length-weight regression data are summarized in table 6.3. A comparison of these data with the results of other studies is enlightening.

As the slope of the length-weight regression increases the weight increase in fish of a given size increases. We can, then, use the slope as a measure of robustness of fish much like the coefficient of condition is used by fishery biologists. We have been able to find data on length-weight relationship for several of our more common fish species.

**Table 6.4 Slopes of Length-Weight Regression for Black Creek and Other Populous of Several Species of Fish**

| Species | Black Creek | Other |
|---|---|---|
| Residents | | |
| Fathead Minnow | 2.81 | 3.24 (Iowa) |
| Johnny Darter | 2.87 | 3.12 (Iowa) |
| Migrants | | |
| White Sucker | 3.03 | 3.08 (Illinois) |
| Common Shiner | 3.27 | 3.29 (Alabama) |
| Mixed | | |
| Creek Chub | 3.21 | 2.98 (Iowa) |

We find that species in which most individuals are resident in Black Creek have lower slopes than other populations of the same species (table 6.4). The two species with strikingly lower slopes are fathead minnow and johnny darter. Species which occur as adults in Black Creek primarily as migrants from the Maumee River have length-weight regression slopes which are similar to those of other populations (table 6.4). Creek chubs seem to be both resident and migratory in Black Creek and have a significantly higher slope than does a similar population in Iowa. This may be due to a mixing of several populations (residents in and out of woods, migrants) in the Black Creek sample or to some other factor.

## 8. SUMMARY

In summary, we have continued to document the effects of disturbance by man and natural events on the fish fauna of Black Creek. A major step in preservation of the fish communities of Black Creek could be taken with more careful consideration of impact of structural or other modifications on fish migration patterns. Preliminary indications are that the health of the biota (fish) of Black Creek is below what might be expected of more natural streams in the mid-western portion of the United States.

# 9. COMMENT

We have been questioned on numerous occasions during our recent field studies with the main point being — "Why do we waste time and money studying a few minnows?"

This is an important question which warrants an answer. The Black Creek study was conceived as a project to clarify the factors responsible for increased sediment and nutrient loads in Lake Erie. These nutrient and sediment inputs have had a significant negative effect on fishery exploitation (sport and commercial) in the Great Lakes in addition to other forms of water-based recreation, and a variety of other urban, domestic, and industrial uses of water.

The Black Creek project is a model project for solving problems within the Lake Erie basin. By carefully evaluating the effects of the activities in the Black Creek study on the biota of the area we can more realistically predict the consequences of management alternatives on a wider geographic area. The fishes of the Black Creek Basin are part of a complex food chain which "feeds" the biotic systems of Lake Erie. Failure in maintaining the biotic systems of Black Creek will inevitably result in failure at the level of the Great Lakes Basin.

We can compare the small streams of the basin to the leaves of a tree (or corn plant). If the leaves, which feed the tree, are diseased the tree will not be healthy and may even die.

# *Nutrients are More Concentrated in Sub-Surface Flow*

**SECTION 7**
Water Quality
Monitoring in
Black Creek
Watershed

**By**
**L. E. Sommers**
**D. W. Nelson**
**E. J. Monke**
**D. Beasley**
**A. D. Bottcher, and**
**D. Kaminsky**

## 1. SAMPLING FACILITIES AND PROCEDURES

### A. Grab samples

Water samples were obtained weekly from 13 sites in the watershed and from one site on the Maumee River. The location of sampling sites is shown in figure 7.1. All water samples are frozen prior to transportation to the Water Analysis Laboratory at Purdue. Grab samples were analyzed for all water quality constituents. Stage measurements are taken at the time of sampling; however, all the streams have not been calibrated so nutrient loadings cannot be computed at this time.

### B. Automatic Pumping Samplers

The automatic pumping samplers (PS-69) were installed at stations 2, 6, and 12 in the Black Creek Watershed and have been operating since February 22, 1975, March 17, 1975, and April 4, 1975, respectively. The stations are located in the lower section of the watershed to allow the sampler data to closely describe the water quality constituents movement from the watershed. The physical operation of the samplers has been very satisfactory (one even continued to operate while being inundated by a severe storm).

The samplers are energized only while the stage in their respective stream is above the one foot level. While energized, the samplers take a 500 ml water sample every thirty minutes with a seventy-two sample capacity (36 hours). The control of

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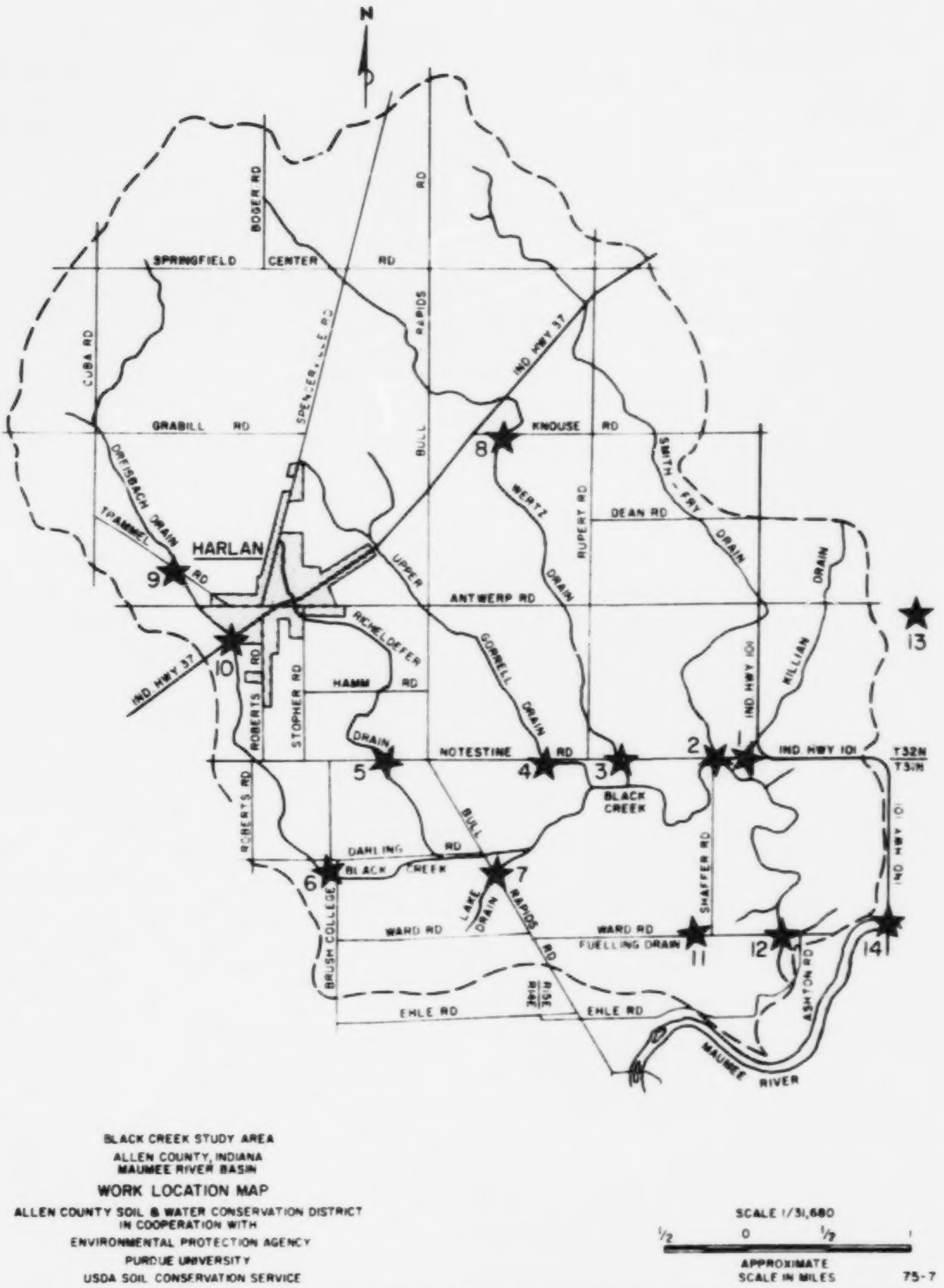
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BLACK CREEK STUDY AREA
ALLEN COUNTY, INDIANA
MAUMEE RIVER BASIN
WORK LOCATION MAP
ALLEN COUNTY SOIL & WATER CONSERVATION DISTRICT
IN COOPERATION WITH
ENVIRONMENTAL PROTECTION AGENCY
PURDUE UNIVERSITY
USDA SOIL CONSERVATION SERVICE
SCALE 1/31,680
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SCALE IN MILES
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Figure 7.1 Location of Sampling Sites for Evaluation of Water Quality

the samplers will be changed to a more meaningful delta stage timing after the new computer system is operational in the watershed. The samples collected are analyzed for the same water quality parameters as the "grab" samplers, namely, ammonium, nitrate, total nitrogen, soluble nitrogen, inorganic phosphorus, total phosphorus, soluble phosphorus, and suspended solids.

Data collected during three storms in late February and mid-March has been analyzed and can be seen graphically in figures 7.2 to 7.13. The twelve figures provide instantaneous water quality data plotted against time, flow hydrographs and loading curves for total nitrogen, total phosphorus and suspended solids. Discussion of these figures is provided in the data analysis section.

### C. Automatic Tile Sampler

An automatic tile sampler is being installed near the Black Creek Watershed to investigate the influence of tile drainage systems on the total water quality of their respective streams. It is known that in some locations as much as 50 percent of the annual sediment loss is coming through the tile outlets. This indicates the vital need for understanding and describing the influence of subsurface drainage in order to complete a reliable watershed model.

The sampler will monitor a 10 inch diameter tile outlet which drains 63 acres of Hoytville silty clay soil. The entire 63 acres are nearly flat and very uniform in soil type. The uniformness of the field will greatly help in developing and verifying a reliable model for tile systems. Crop cover for the field is a standard corn-soybean rotation.

The above described field is not in the Black Creek Watershed because a uniform well managed tile system could not be located within the project boundary. The systems in the watershed either lacked a tile line layout record or were only put in within the past three years. Even though the tile sampler site is not in the watershed it well represents the tile drainage systems in the Black Creek Watershed.

The sampler will have the capability of collecting 72-500 ml water samples on a constant volume passed basis. The sampling rate will be approximately 1 sample per 30 minutes at maximum flow and 0 at no flow with a linear response to intermediate flows. A flow record will be made continuously and an event mark on the flow record will designate when a sample was taken. The sampler station will have a 350 gpm pump in conjunction with a sump to prevent the tile outlet from being inundated during storm events. During low flows, the outflow will pass directly through the station with no pumping required.

The tile sampler should be operational by October of 1975.

## 2. WATER ANALYSIS LABORATORY

Water samples are being analyzed in accordance with procedure set forth in the work plan. The only procedural modification instituted involves analysis of samples collected with the pump samplers. Initial data indicated that the concentration of all water quality parameters was essentially constant during the declining phase of the hydrograph. Since the pump samplers generate large numbers of samples in a one to two day period, it was felt that a preliminary screening technique should be evaluated to reduce the number of samples requiring analysis. In all subsequent storm events all pump samples will be assayed for turbidity using a Klett-Summerson colorimeter fitted with a No. 42 filter. The turbidity data is then used to construct a rough hydrograph. All samples are analyzed during the periods of increasing and peak flow; however, as the flow levels off, the frequency of samples chosen for analysis will be decreased. This technique allows accurate evaluation of all storm events and yet minimizes the total number of samples requiring analysis.

The concentrations of soluble and total carbon are not included in the report. Several modifications are in progress to facilitate carbon analyses with the Dohrman instrument. It is anticipated that all changes will be completed in the near future and the carbon analyses of water samples will be resumed. The laboratory located at Fort Wayne has initiated filtering a portion of all water samples through a 0.45 mm Nucleopore filter prior to freezing. This is necessary because preliminary data indicated that soluble inorganic phosphorus levels are altered if non-filtered samples are frozen. Due to the number of samples produced by the pump samplers, it is not feasible from a practical standpoint to filter these water samples.

## 3. DATA HANDLING AND EVALUATION

The Black Creek Study water quality, rainwater quality, rainulator water quality, pump sampler water quality, rainfall, stage recorder, and tile drain data are now being stored and manipulated on Purdue's Miracle and CDC 6400/6500 computer systems. The data from the various samplers and sensors are being combined into a format that is practically identical to the Environmental Protection Agency STORET-system's DIP-format.

The water quality data and pump sampler data have been combined with stage data for a particular station in order to obtain flow (from a rating curve and equation) and loading data on an instantaneous basis. The pump sampler data can then be plotted chronologically to give a very good picture of both the flow and loading hydrographs for all of the measured parameters.

Once the data has been keypunched and entered into the computer (small batches of data are entered from on-line video or teletype terminals), the data is sorted by site number and placed in chronological order. A file is also created using the laboratory reference number sequence as the sorting criteria. The data is then checked for obvious errors (parameters out of range, improper characters, incorrect number of parameters, etc.). When the data is flagged, the questionable card is hand checked against the original laboratory data sheet and corrected, if necessary. The computer file is then updated and STORET-format cards are punched for delivery to EPA.

Next, a statistical analysis program is run using the stored data on a site-by-site or entire watershed basis. The calculated statistics include monthly and yearly means, maximums, and minimums; median values; and standard deviations. The above statistics are calculated on both a concentration and loading basis.

Once it has been ascertained that everything is reasonable, the data is entered into a CDC 854 Disk Pack for later use in simulation and modeling studies on the CDC 6400/6500 system. The disk pack will allow for storage of all of the data that has been collected and for retrieval of any data at any time for modeling work or data analysis (this is a much faster method than using magnetic tapes or similar storage media).

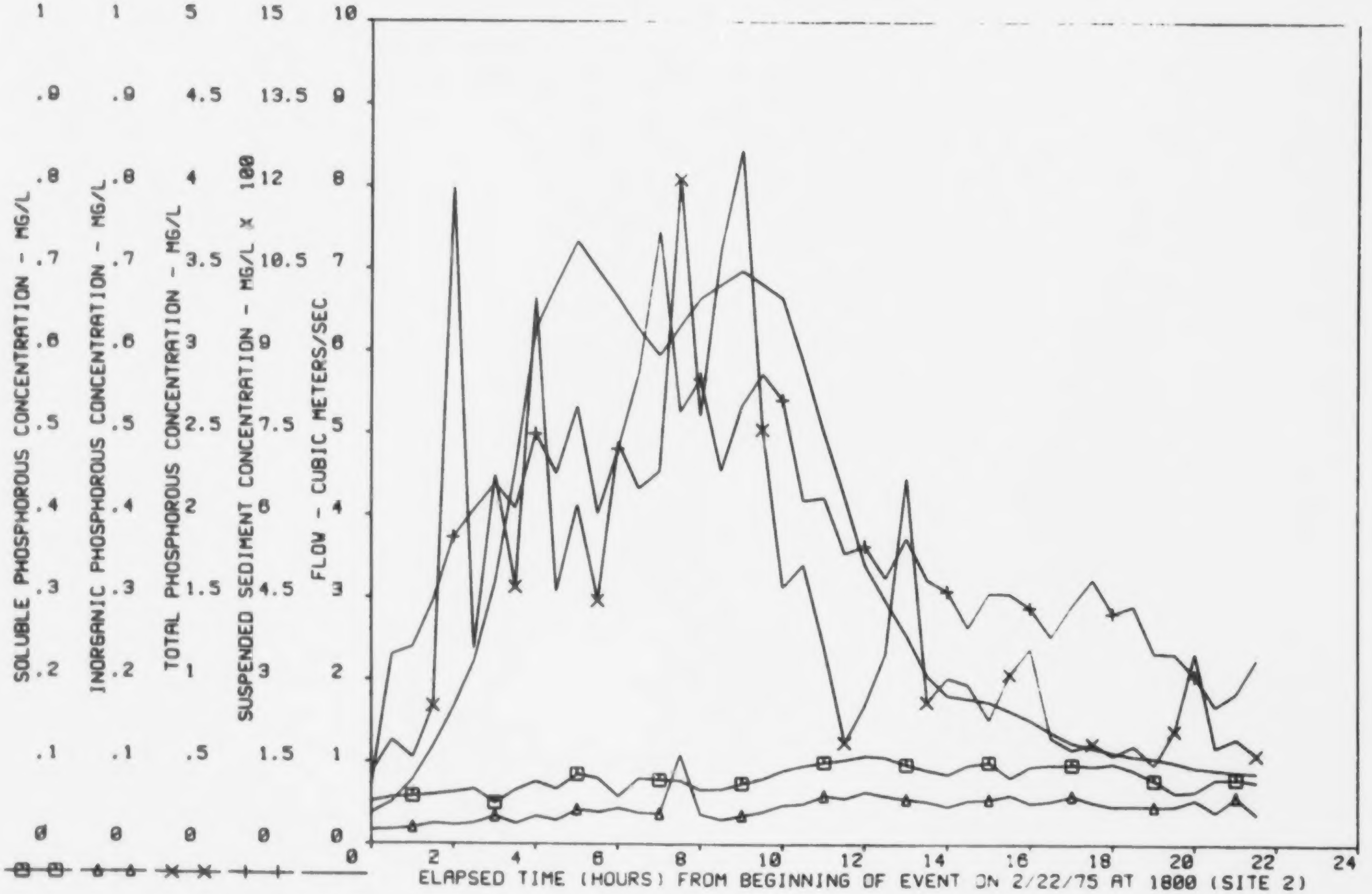


Figure 7.2 Concentrations of P and Solids and Flow for an Events Occurring at Site 2 on February 2, 1975

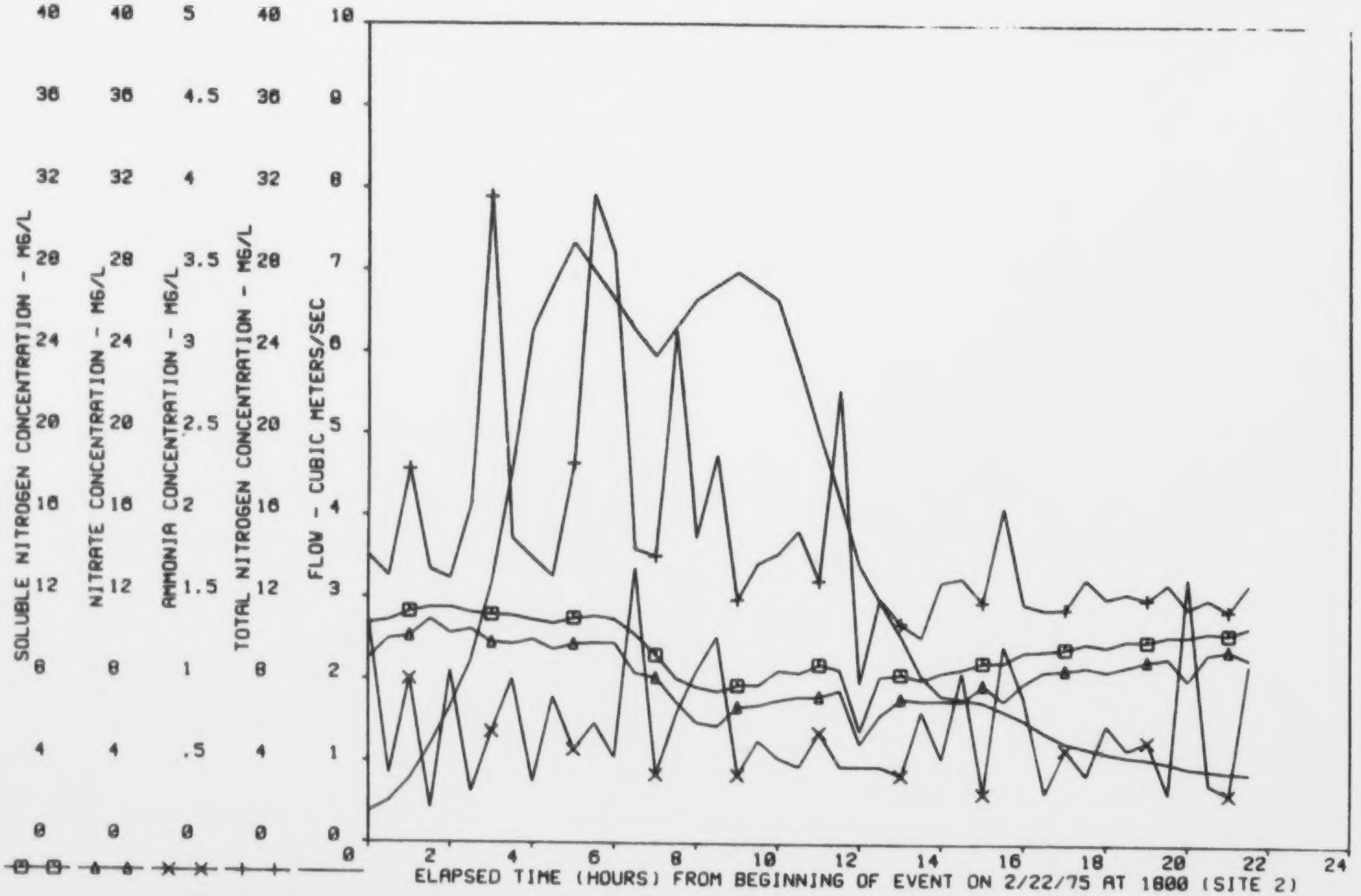


Figure 7.3 Concentration N and Flow for an Event Occurring at Site 2 on February 2, 1975

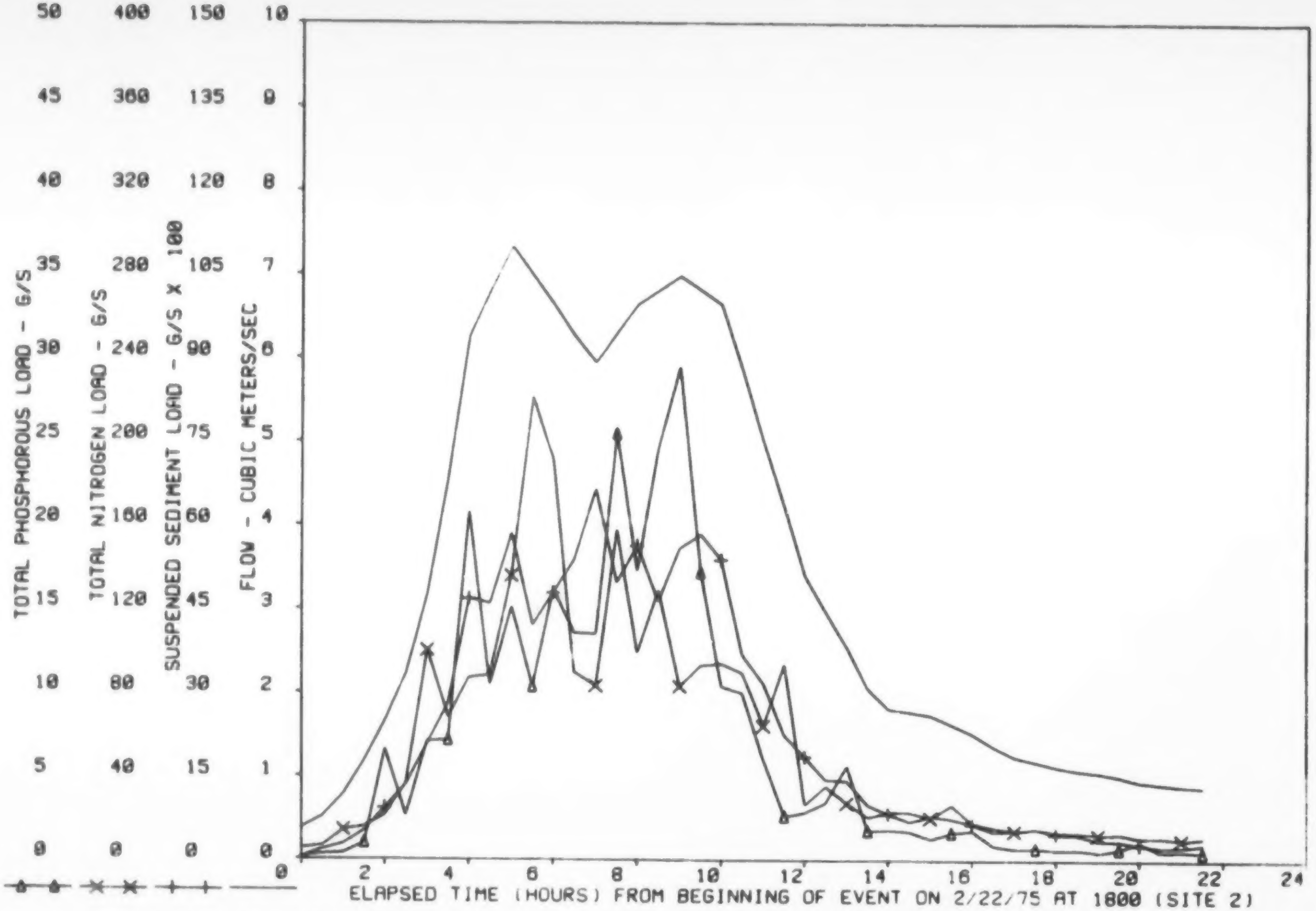


Figure 7.4 Loading of N, P, and Solids for an Event Occurring at Site 2 on February 2, 1975

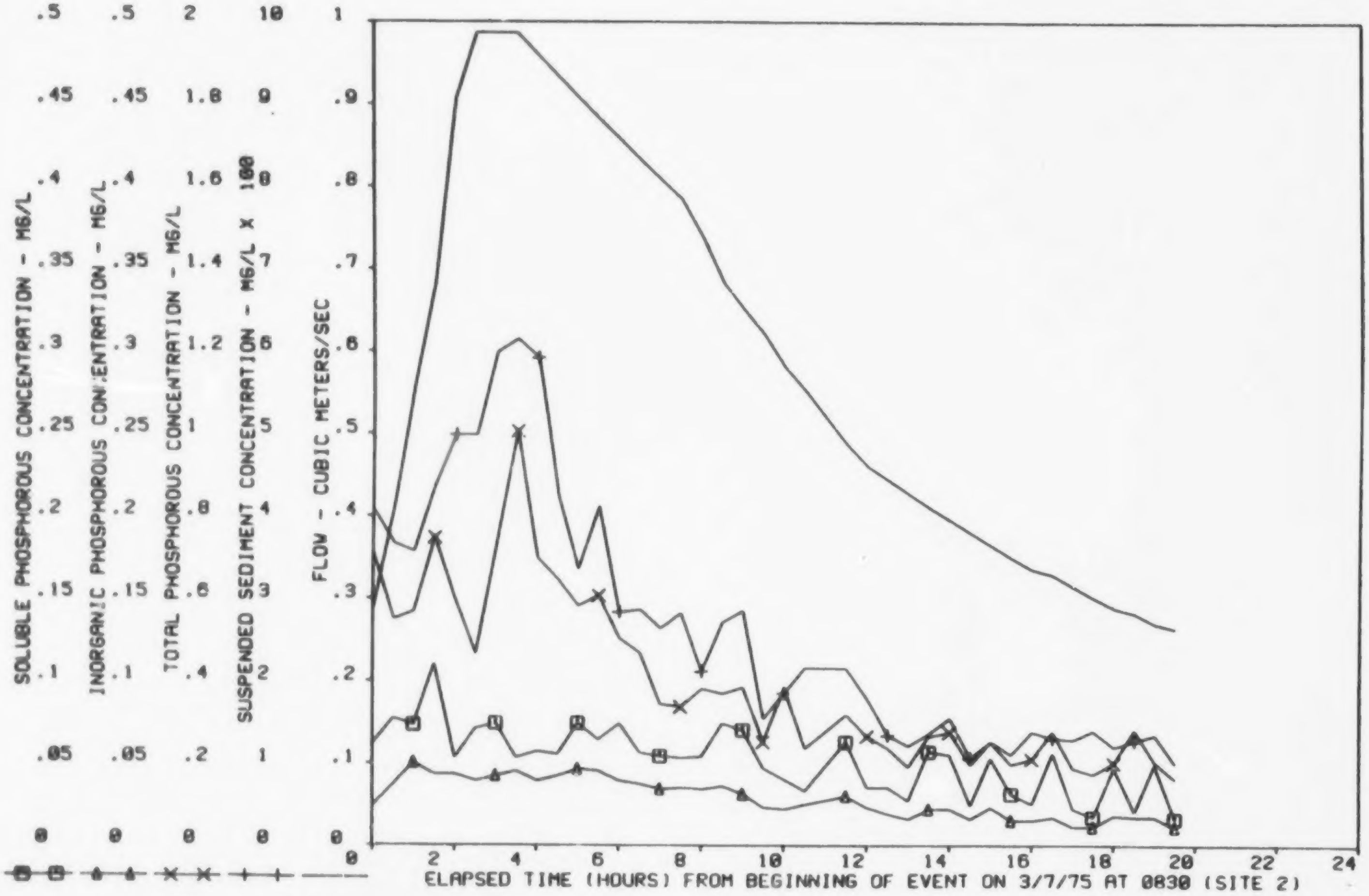


Figure 7.5 Concentrations of P and Solids and Flow for and Event Occurring at Site 2 on March 7, 1975

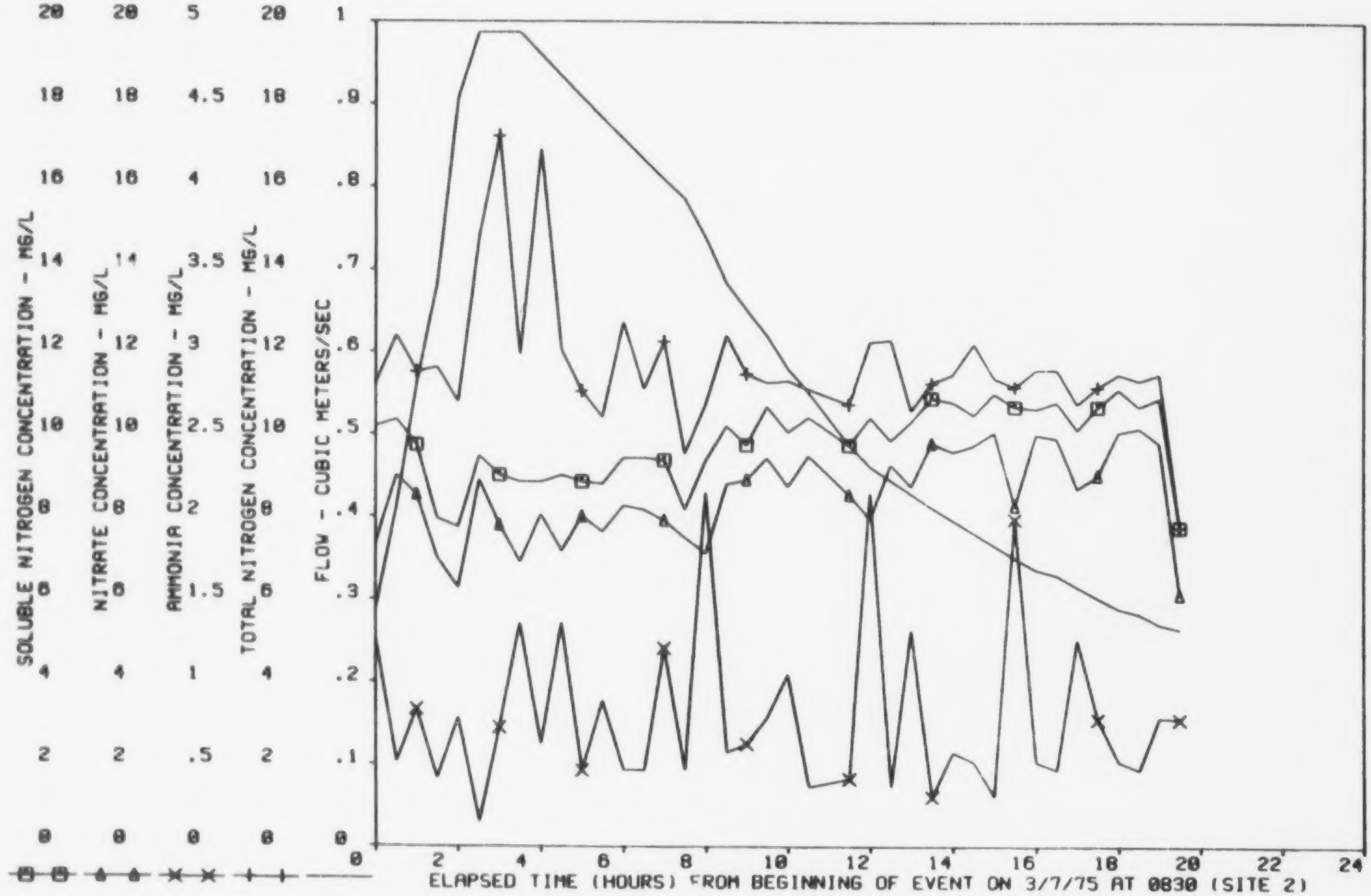


Figure 7.6 Concentration of N and Flow and Event Occurring at Site 2 on March 7, 1975

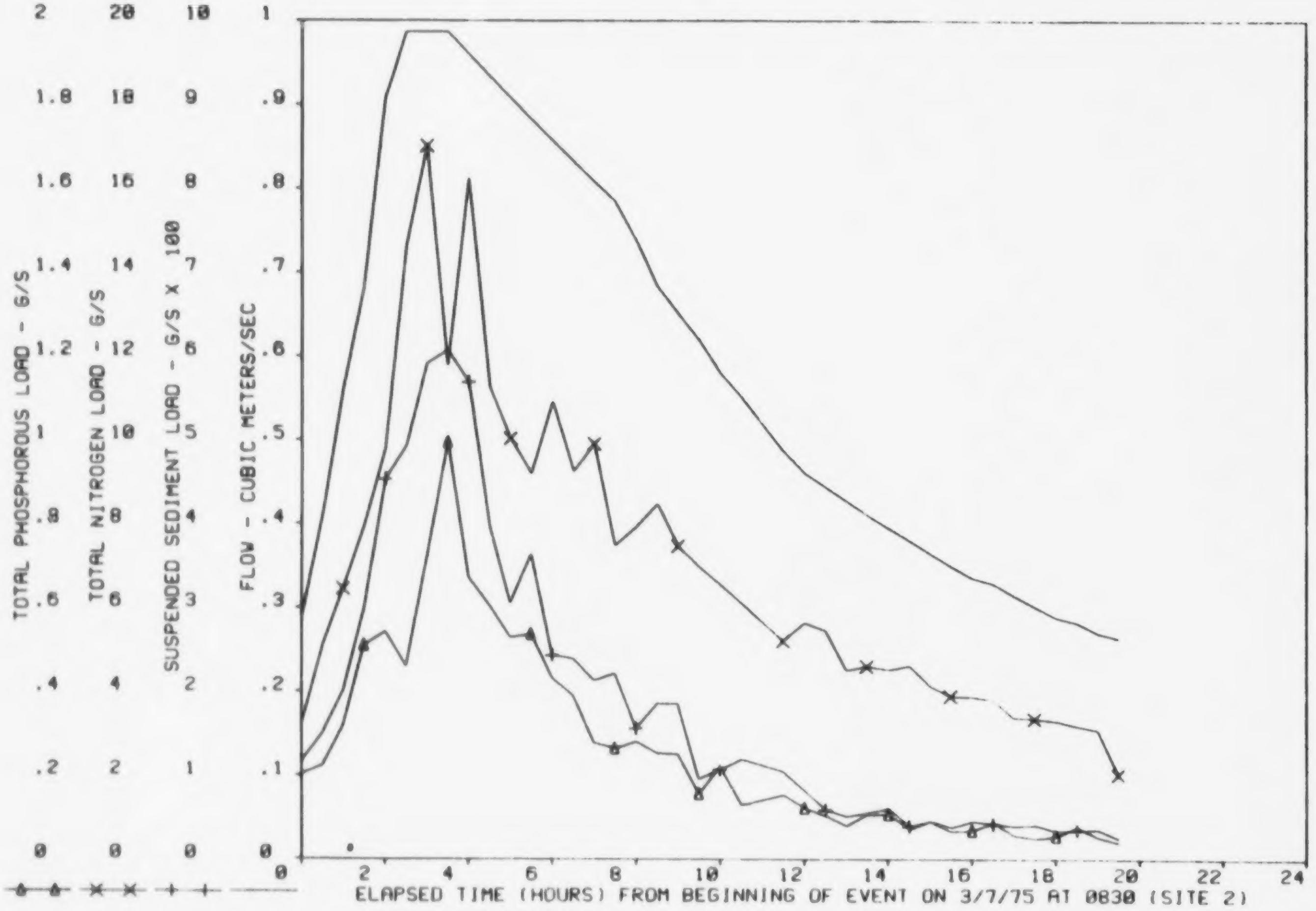


Figure 7.7 Loading of N, P, and Solids for an Event Occurring at Site 2 on March 7, 1975

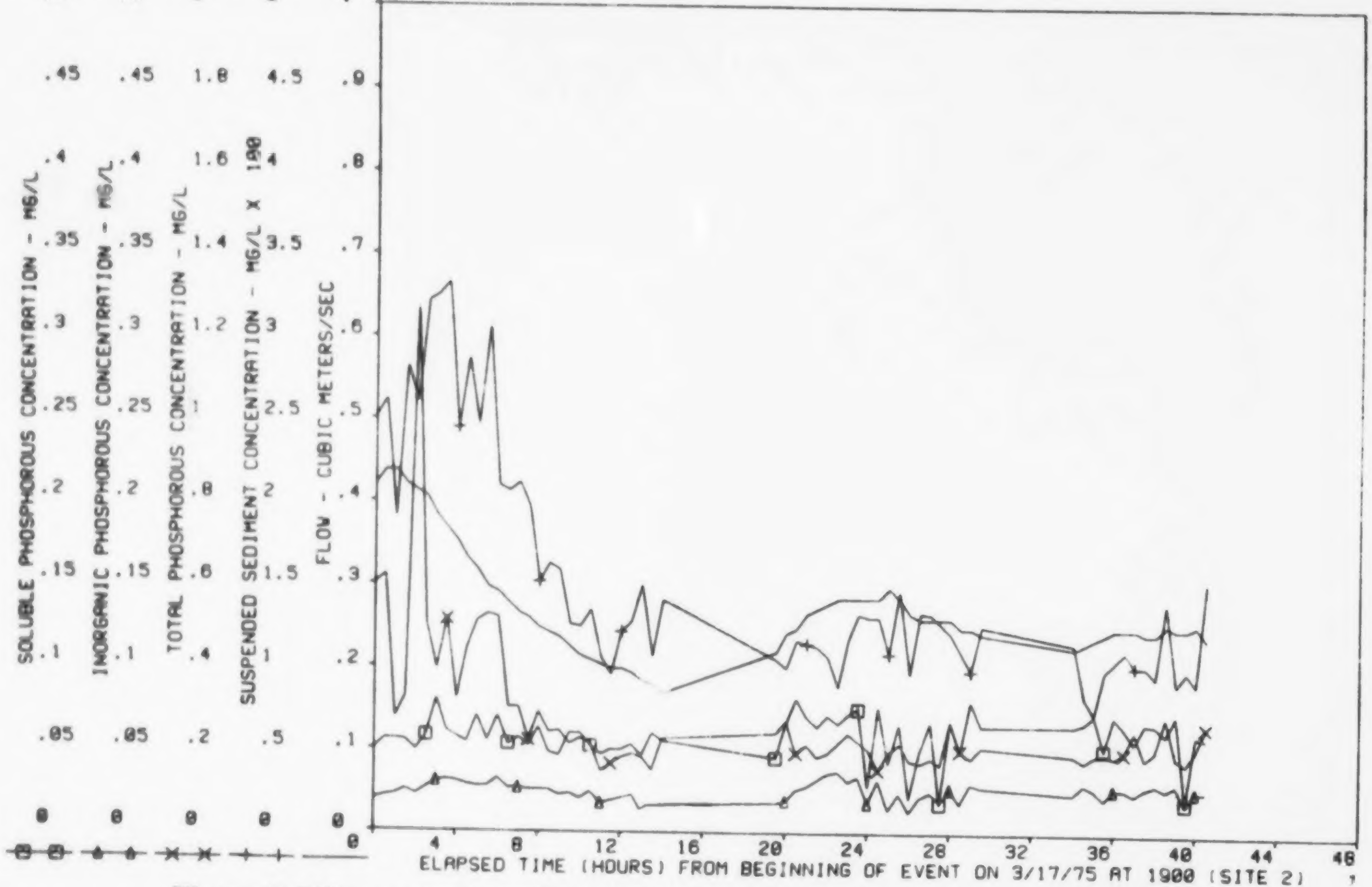


Figure 7.8 Concentration of P and Solids and Flow for an Event Occurring on Site 2 on March 17, 1975

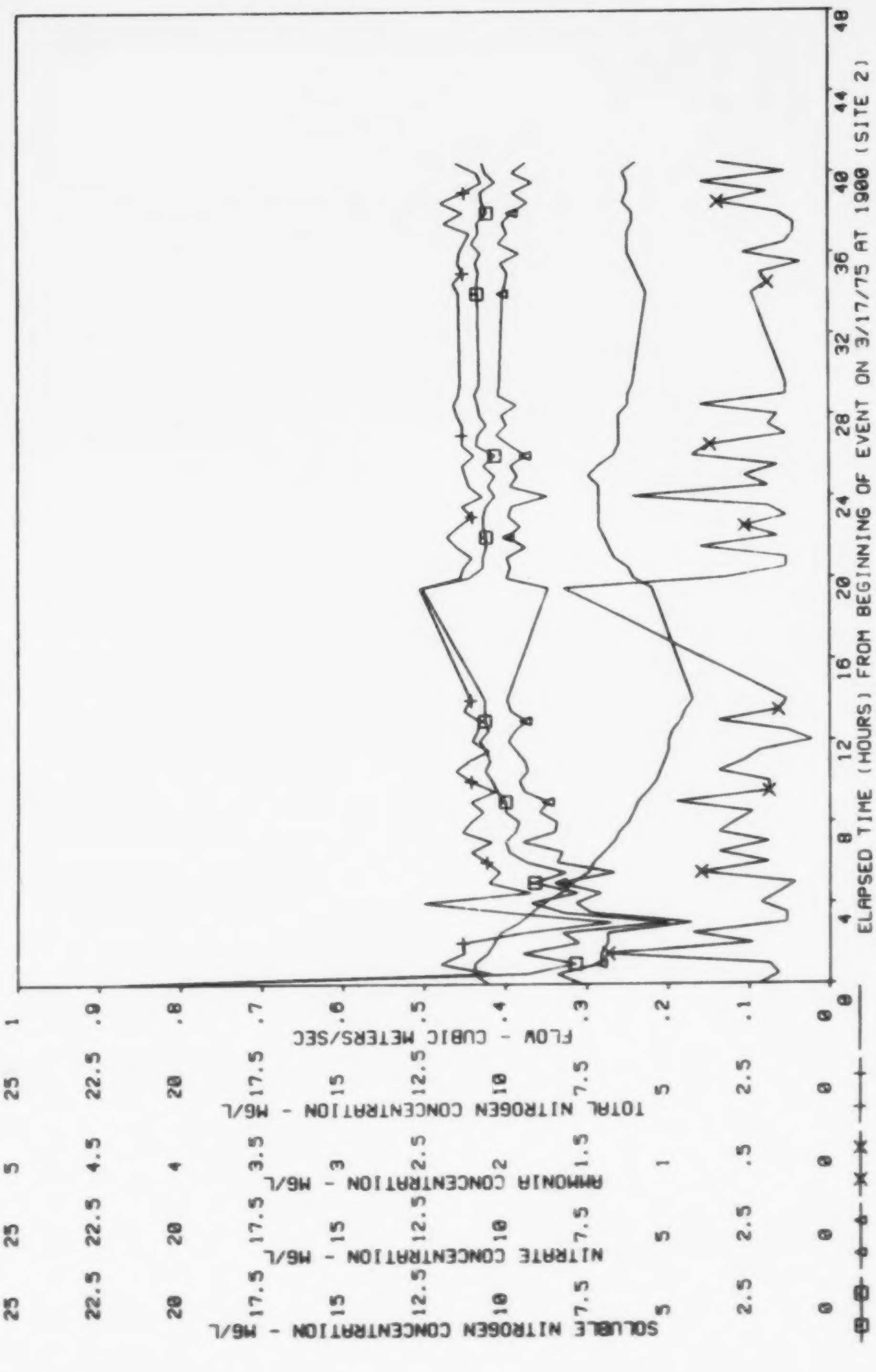


Figure 7.9 Concentration of N and Flow for an Event Occurring at Site 2 on March 17, 1975

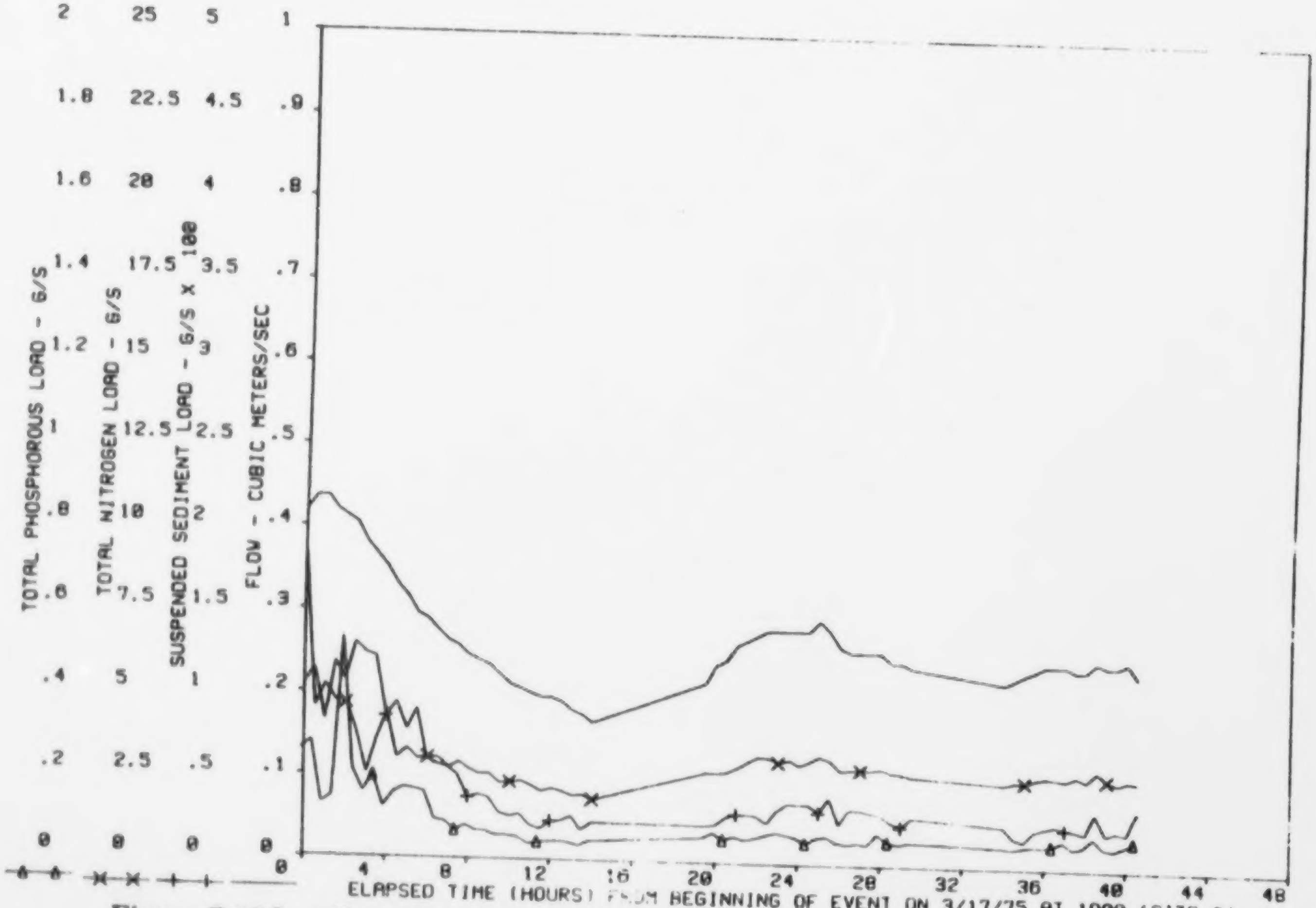


Figure 7.10 Loading of N, P, and Solids for an Event occurring at Site 2 on March 17, 1975

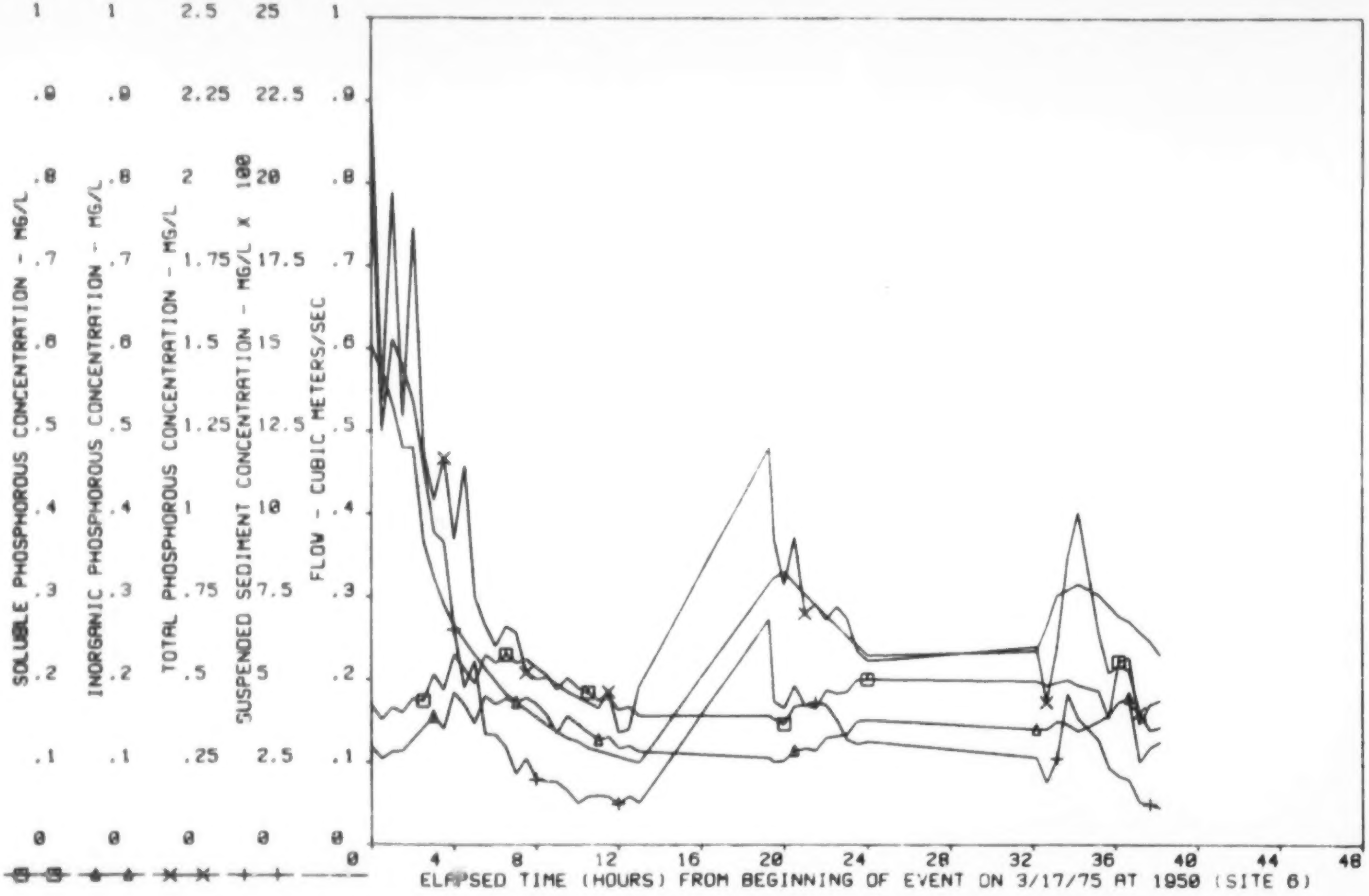


**Figure 7.11 Concentrations of P and Solids and Flow for an Event Occurring at Site 6 on March 17, 1975**

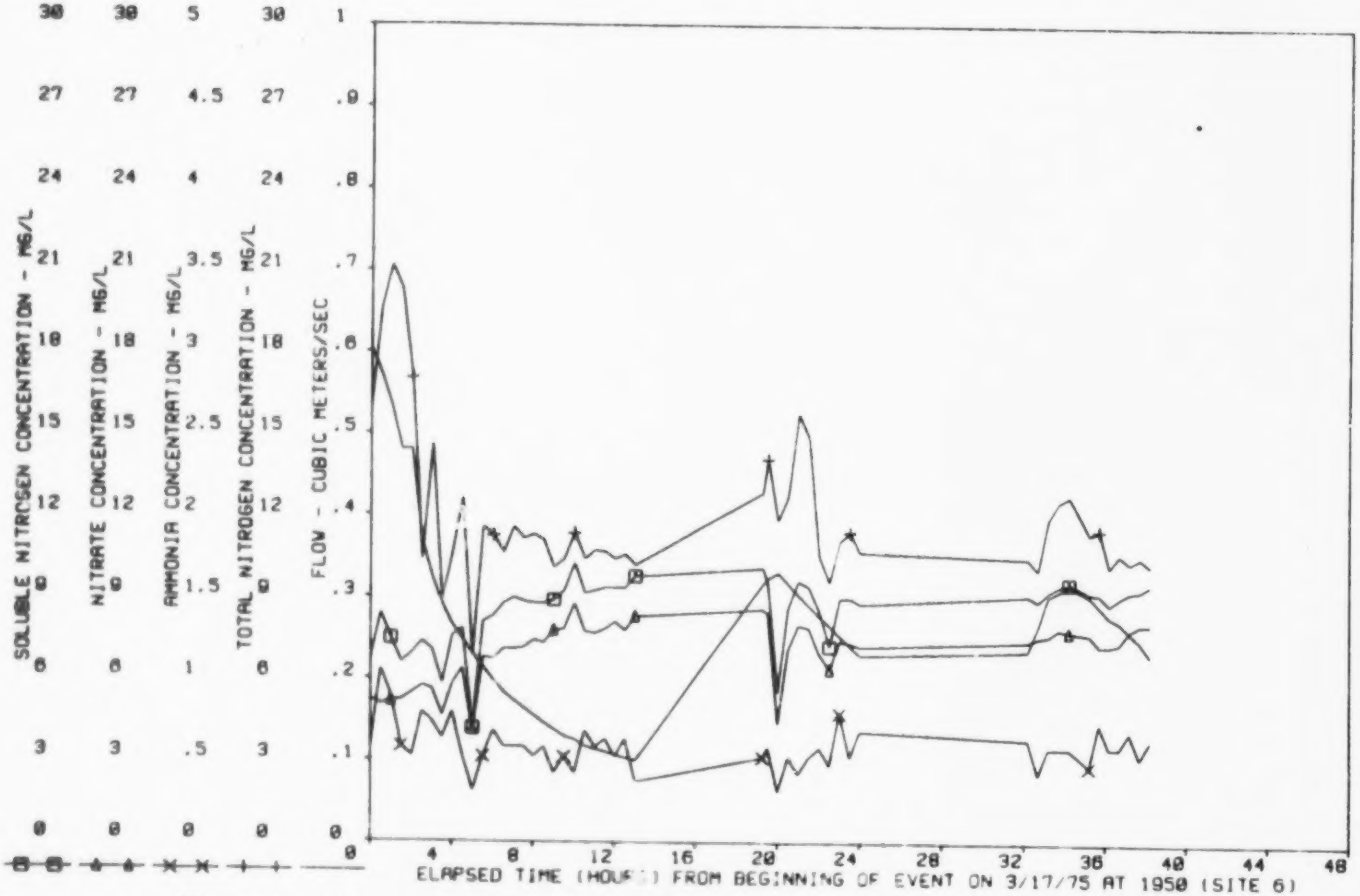


Figure 7.12 Concentration of N and Flow for an Event Occurring at Site 6 on March 17, 1975

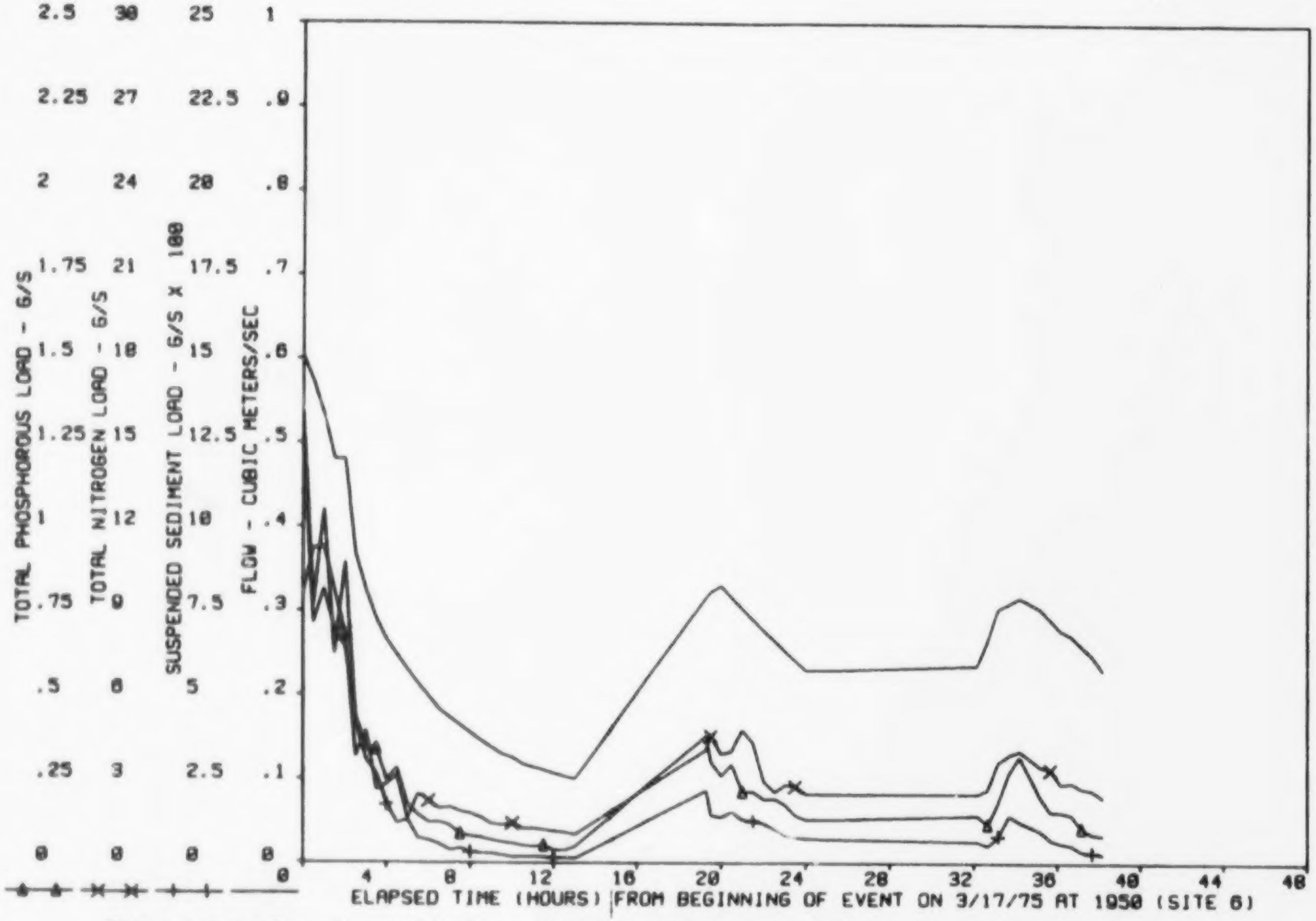


Figure 7.13 Loading of N, P, and Solids for an Event Occurring at Site 6 on March 17, 1975

The rainfall and stage data are being entered continuously. This allows the programmer to recall the data for long periods of record or for short periods by simply specifying a beginning and an ending date. A plotting program has been developed that will present the rainfall or flow data in a cumulative plot for any three-month or one-year period (see figures 7.14 to 7.21).

# 4. WATER QUALITY MONITORING

## A. Grab Samples

Data for suspended solids, ammonium, nitrate, total soluble nitrogen, total nitrogen, dissolved inorganic phosphorus, total soluble phosphorus, total phosphorus and stage are presented in tables 7.1 to 7.5. The following abbreviations are used in the tables:
SUS-S suspended solids
NH4-N ammonium nitrogen
NO3-N nitrate nitrogen
TOT-N total nitrogen (unfiltered sample)
SOL-N total soluble nitrogen (filtered sample)
F-P soluble inorganic P (sample filtered after freezing)
TOT-P total phosphorus (unfiltered sample)
SOL-P total soluble phosphorus (filtered sample)
STAGE distance from fixed point above stream
The results represent analysis of approximately 150 samples collected from each of the 14 sampling sites during the March 19, 1973, to December 29, 1974, time period. The number of samples (N) is not the same for all water quality parameters because it was not possible to analyze duplicate samples for all components. The data are summarized by presenting the range, median, mean, standard deviation and coefficient of variation (CV) for each component. The CV was computed to assist in evaluating the variability associated with the various components analyzed in water samples. Inspection of the CV values for the various sites indicate that nitrate nitrogen, total soluble nitrogen, and total nitrogen are the least variable constituents in water samples. In contrast, suspended solids, ammonium nitrogen, and phosphorus forms possess CV's often times in excess of 100 percent.

For many constituents in natural waters a wide range of values is found. Due to this variability, the median concentration, rather than the mean, was selected to characterize the central tendency for water quality, i.e., use of the median eliminates the bias inherent in the mean if a population contains several very high or low data points. This is readily seen by comparing the mean and median concentrations for all components at the 14 sites. The median and mean values for N components were similar whereas the median was, in general, from 50 to 75 percent of the mean for solids and phosphorus components. These data suggest that several storm events during the year result in large amounts of solids and phosphorus entering the streams, causing an elevated mean concentration. In contrast, the levels of nitrogen in water are more constant and, even though storm events result in increased runoff, the impact of runoff is not reflected in the concentration of nitrogen components. Obviously, all runoff is not reflected in the concentration of nitrogen

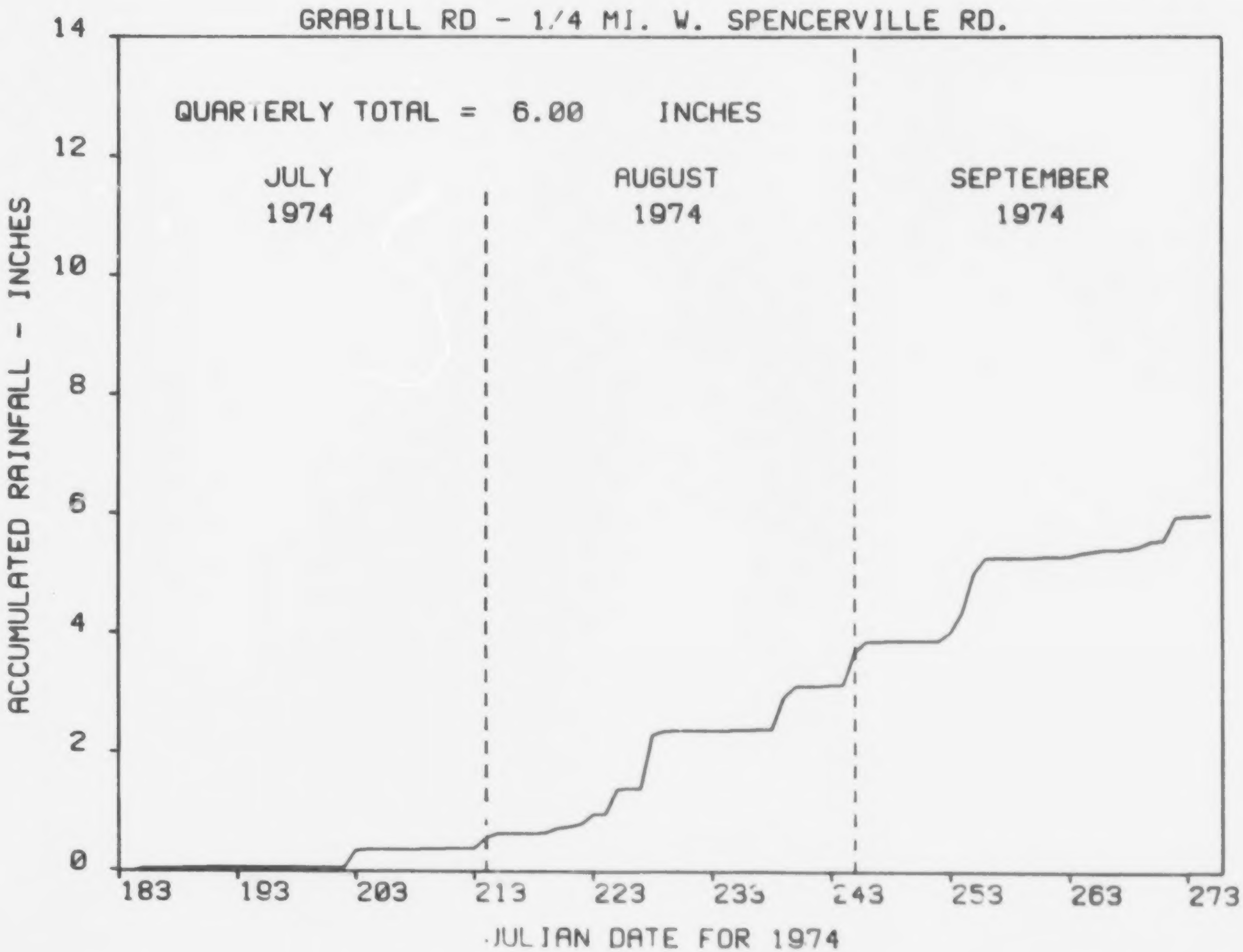


Figure 7.14 Rainfall Data for 1974

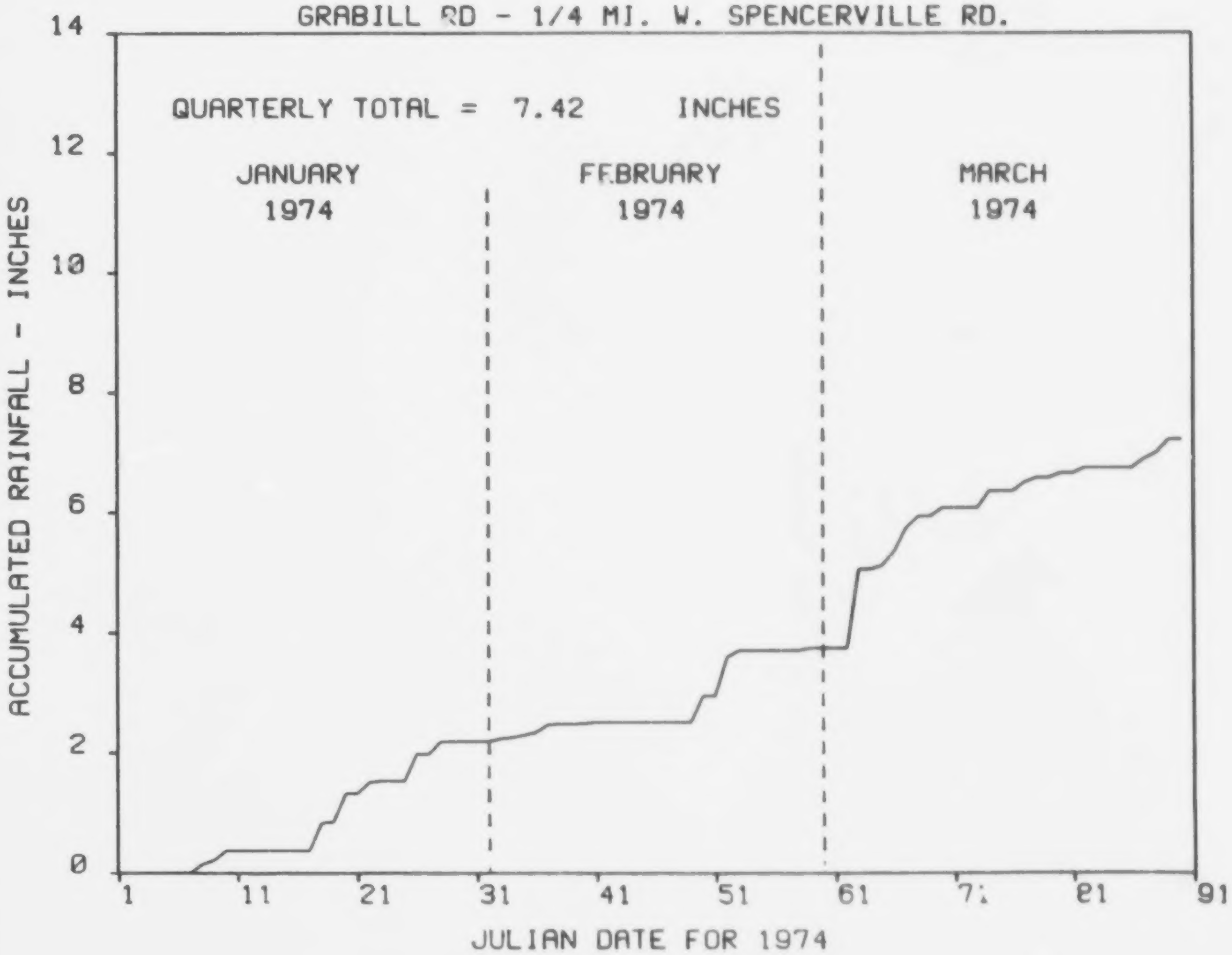


Figure 7.15 Rainfall Data for 1974

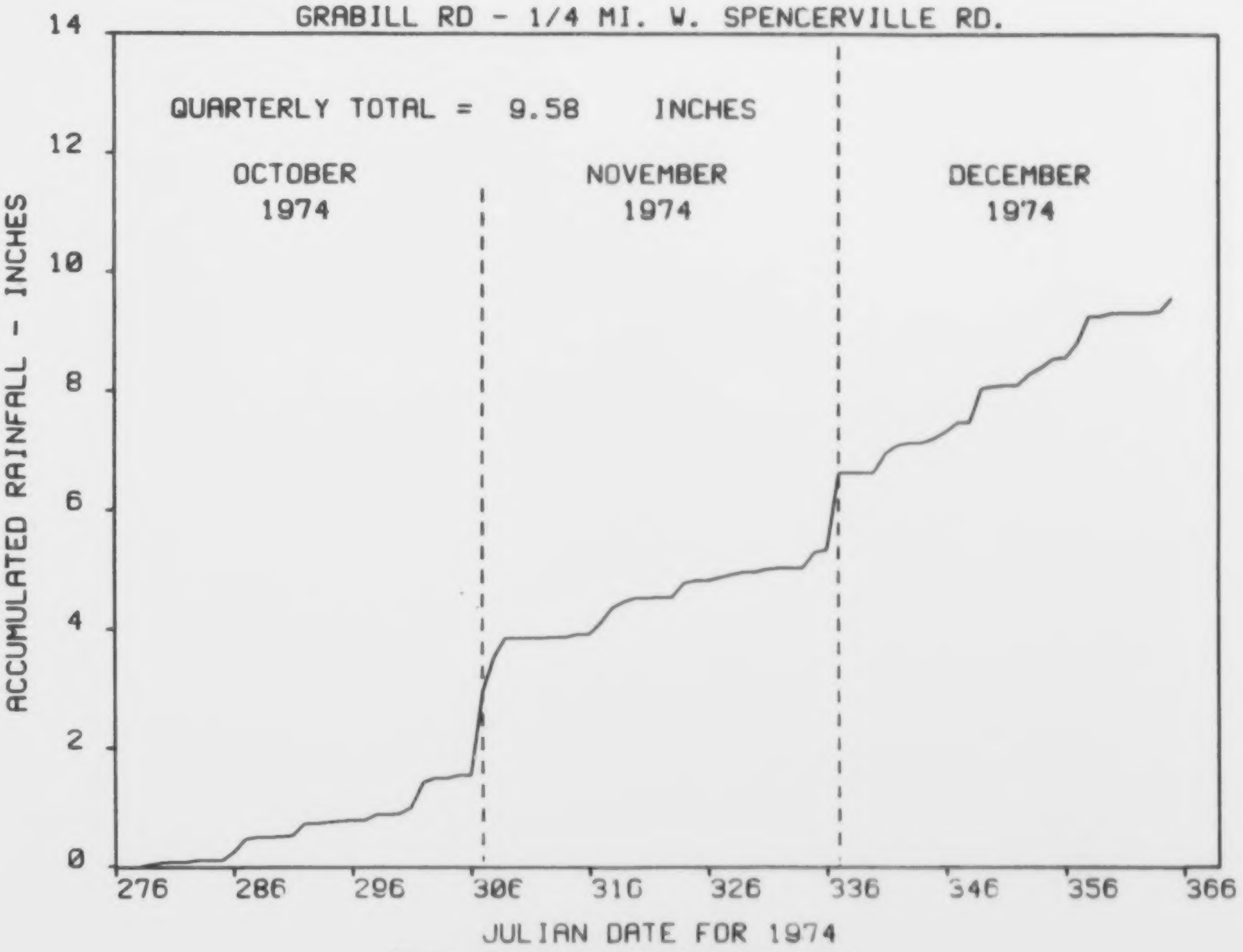


Figure 7.16 Rainfall Data for 1974

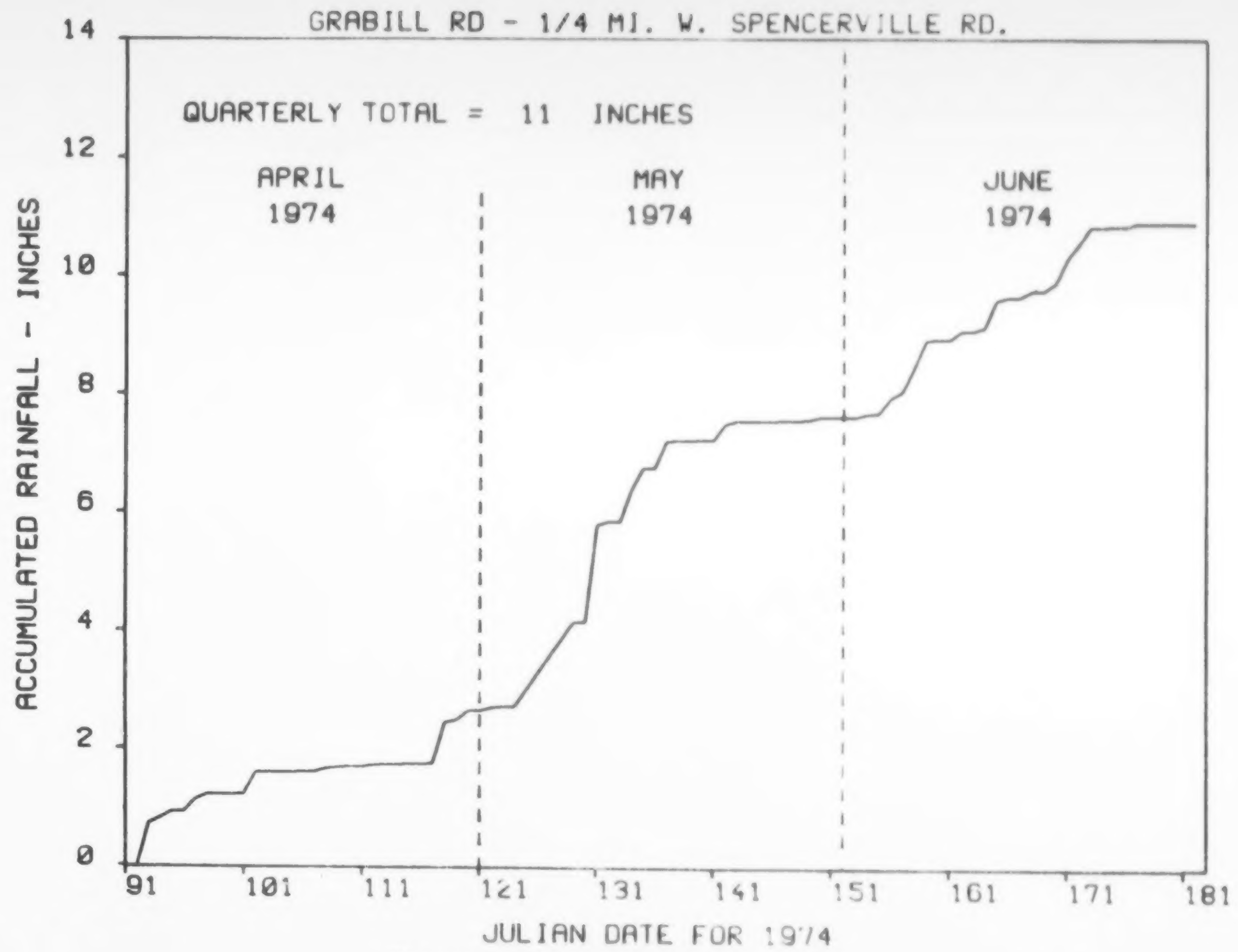


Figure 7.17 Rainfall Data for 1974

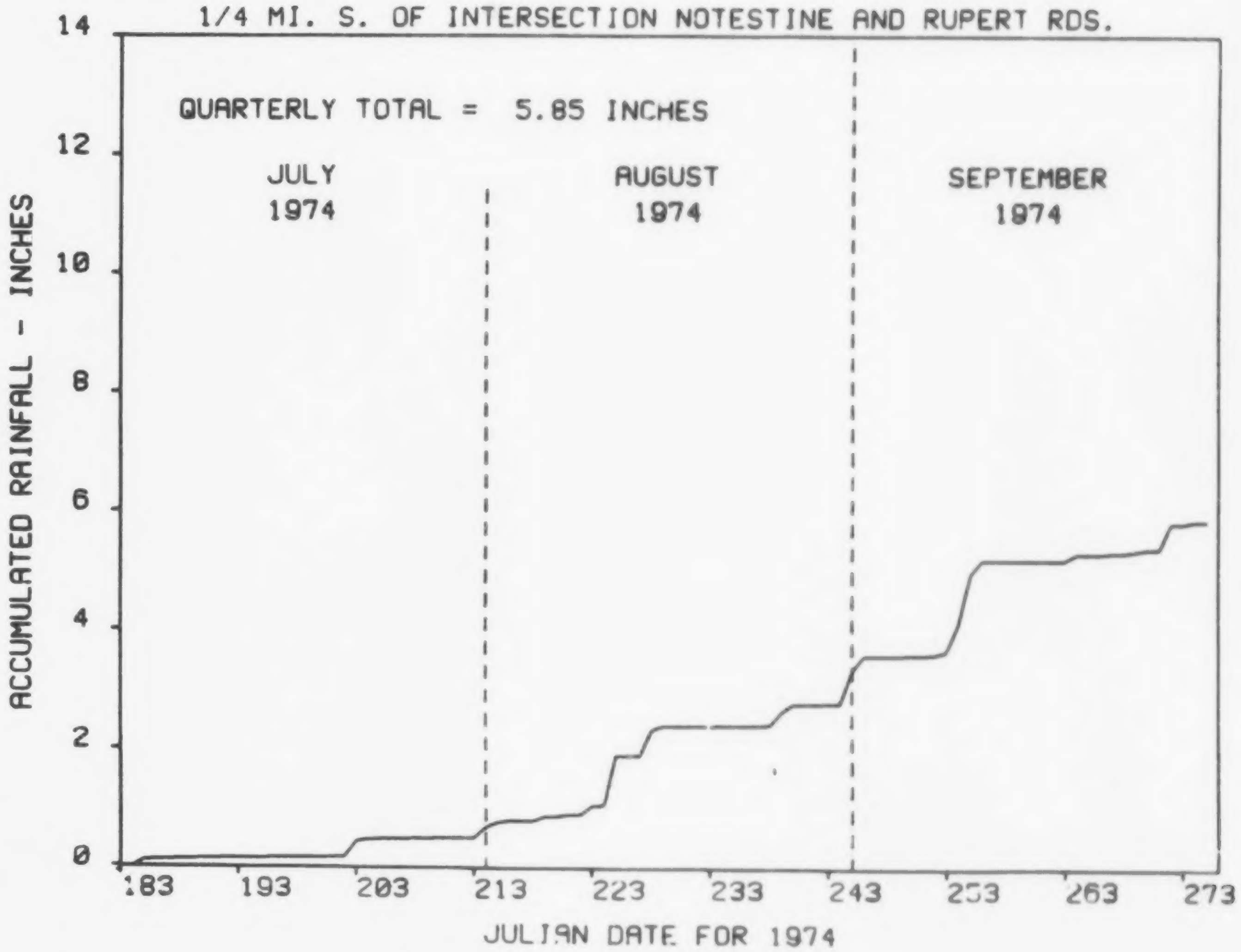


Figure 7.18 Rainfall Data for 1974

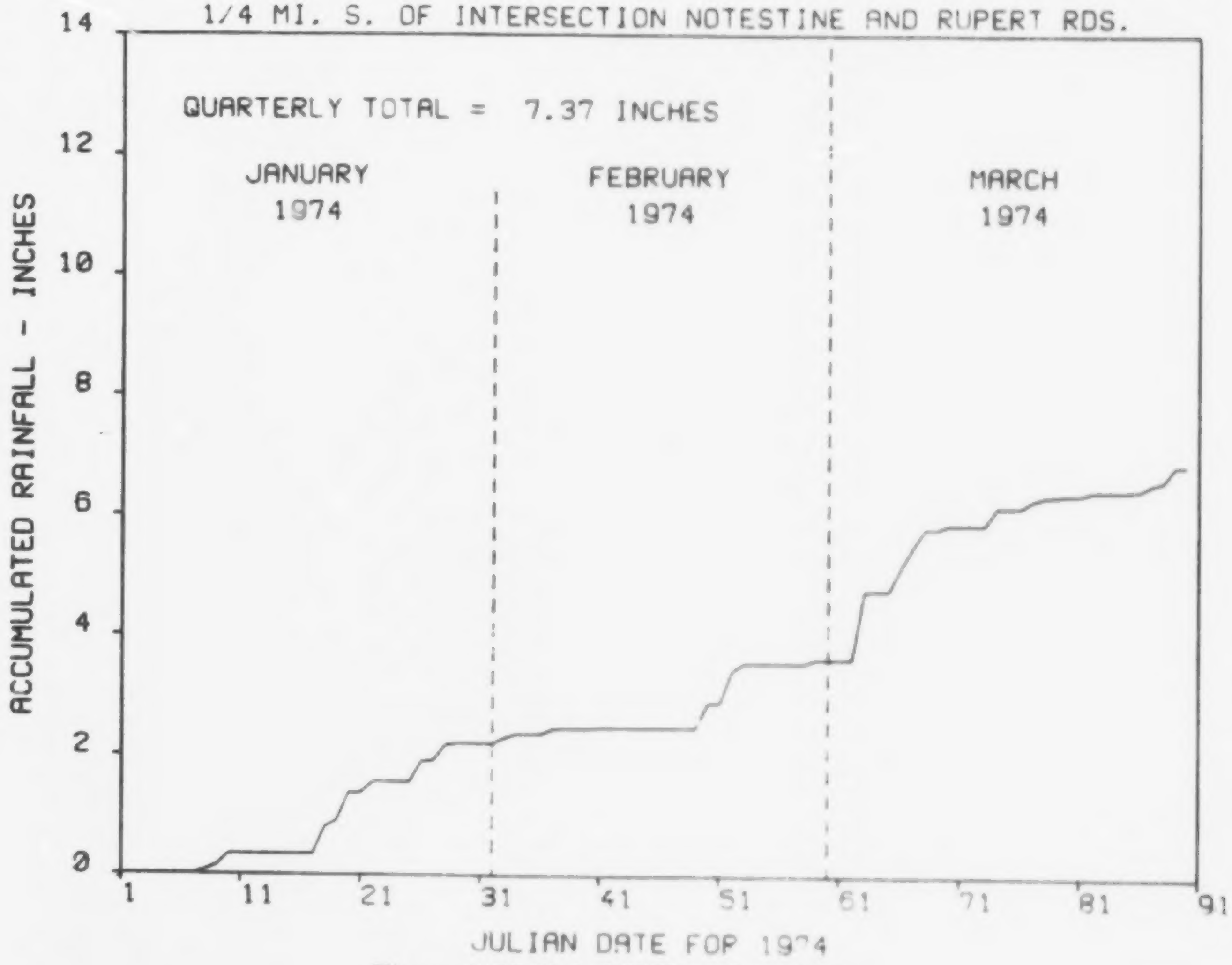


Figure 7.19 Rainfall Data for 1974

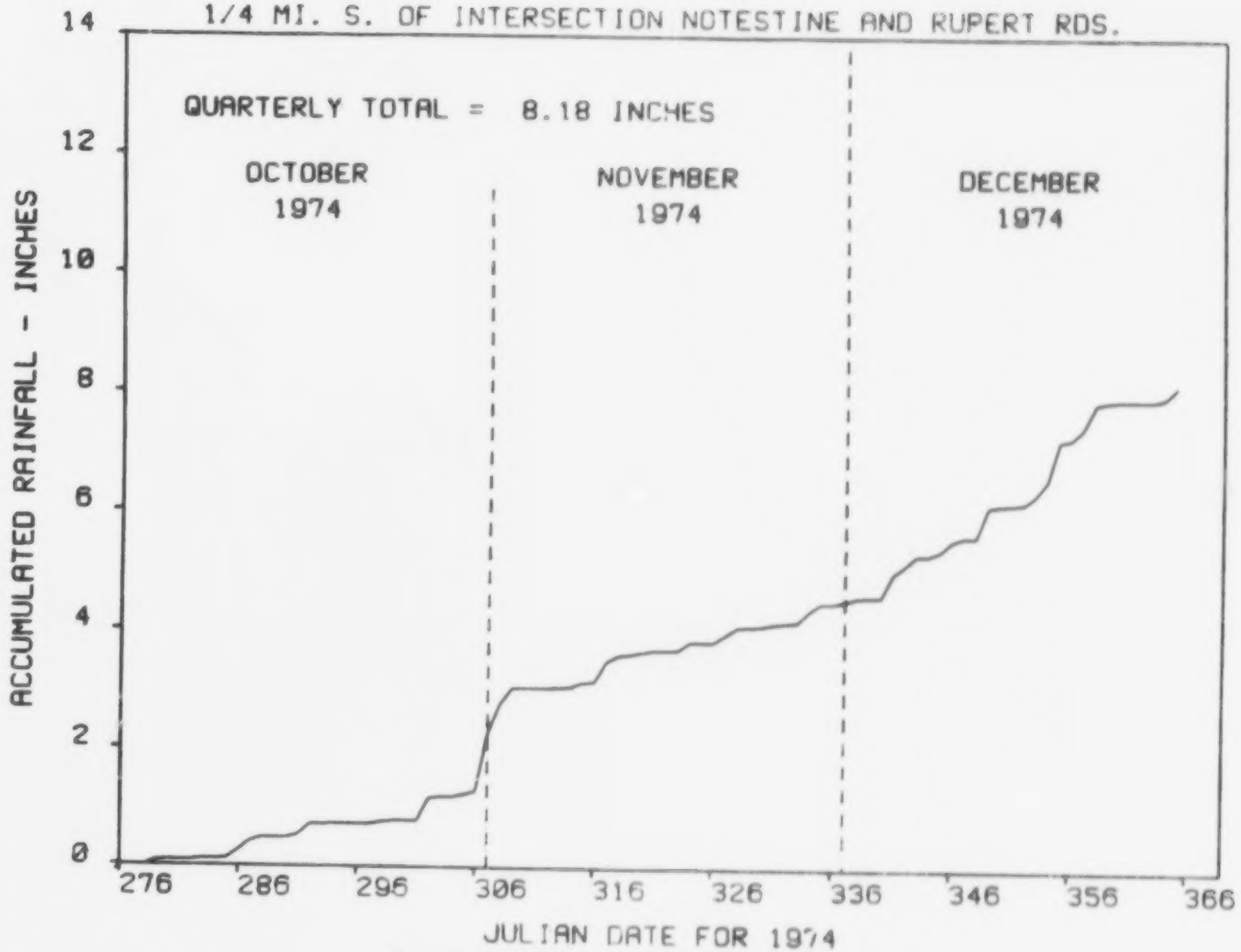


Figure 7.20 Rainfall Data for 1974

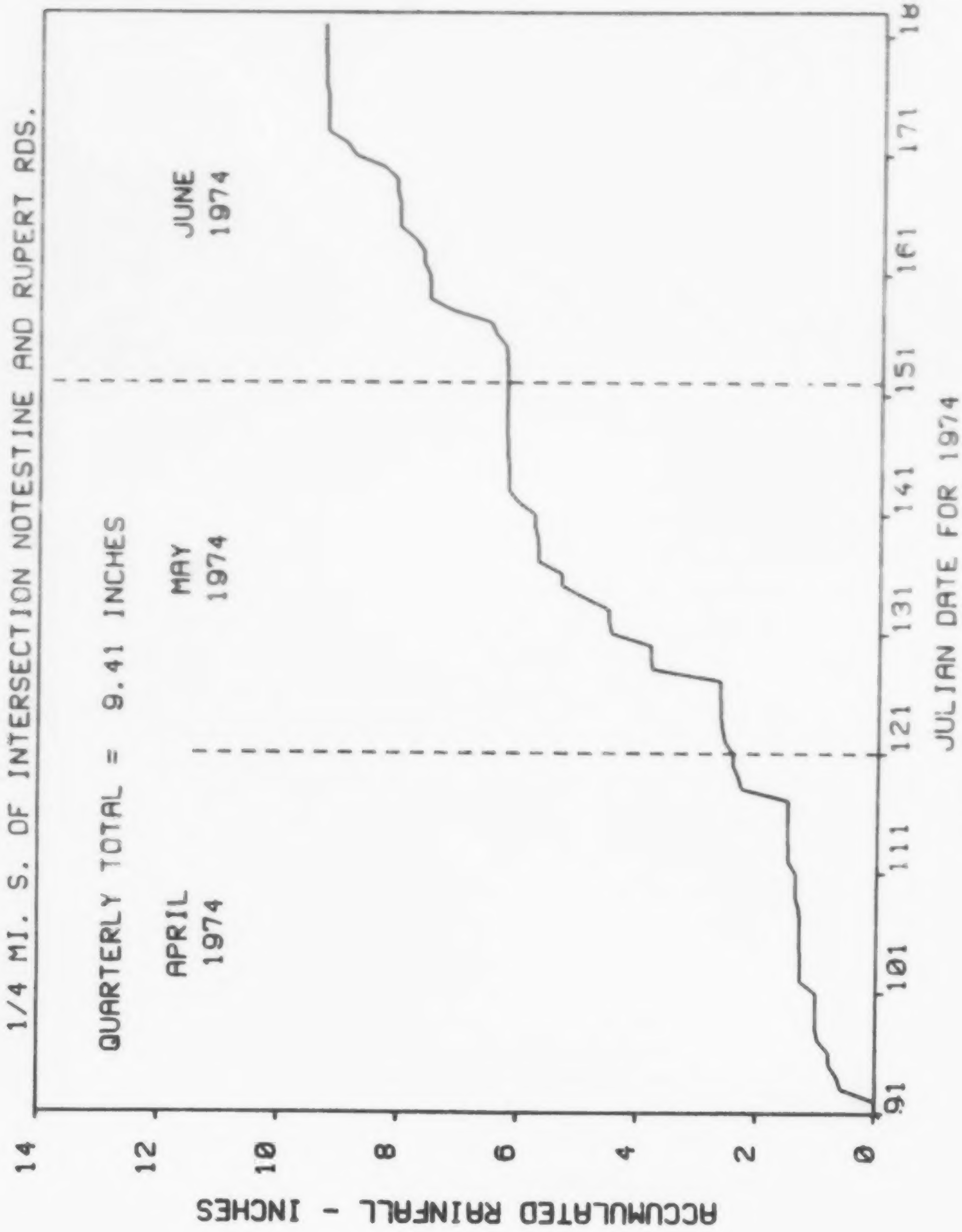


Figure 7.21 Rainfall Data for 1974

**Table 7.1 Water Quality Data for Grab Samples Obtained from Sites 1, 2, and 3**

Site No. 1 (149 samples: 3-19-73 to 12-29-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 74 | 18.000 | 935.500 | 128.500 | 175.766 | 162.46 | 92.4 |
| NH4-N | 74 | 0.023 | 1.325 | 0.253 | 0.313 | 0.26 | 82.3 |
| NO3-N | 74 | 0.140 | 16.970 | 7.438 | 7.023 | 3.99 | 56.9 |
| TOT-N | 74 | 0.545 | 23.820 | 8.425 | 8.497 | 4.54 | 53.4 |
| SOL-N | 74 | 0.275 | 15.770 | 7.015 | 6.819 | 3.79 | 55.6 |
| F-P | 74 | 0.002 | 0.713 | 0.041 | 0.069 | 0.10 | 141.0 |
| TOT-P | 74 | 0.008 | 1.479 | 0.181 | 0.282 | 0.28 | 101.1 |
| SOL-P | 74 | 0.003 | 2.425 | 0.064 | 0.124 | 0.29 | 234.1 |
| STAGE | 72 | 2.420 | 5.200 | 4.650 | 4.538 | 0.52 | 11.3 |

Site No. 2 (156 samples: 3-19-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 78 | 18.000 | 1111.000 | 117.750 | 173.979 | 194.64 | 111.9 |
| NH4-N | 78 | 0.025 | 2.190 | 0.250 | 0.353 | 0.37 | 103.5 |
| NO3-N | 78 | 0.095 | 13.810 | 5.700 | 5.467 | 3.09 | 56.5 |
| TOT-N | 78 | 0.860 | 16.675 | 6.820 | 6.547 | 3.30 | 50.4 |
| SOL-N | 78 | 0.705 | 11.475 | 5.658 | 5.500 | 2.85 | 51.8 |
| F-P | 78 | 0.004 | 0.252 | 0.021 | 0.033 | 0.04 | 116.6 |
| TOT-P | 77 | 0.005 | 1.730 | 0.152 | 0.240 | 0.28 | 116.3 |
| SOL-P | 74 | 0.001 | 1.130 | 0.054 | 0.078 | 0.14 | 181.4 |
| STAGE | 75 | 11.400 | 15.500 | 14.900 | 14.692 | 0.78 | 5.3 |

Site No. 3 (157 samples: 3-19-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 80 | 12.000 | 1259.500 | 124.500 | 185.853 | 208.87 | 112.4 |
| HN4-N | 79 | 0.025 | 1.995 | 0.260 | 0.358 | 0.36 | 101.0 |
| NO3-N | 79 | 0.040 | 13.080 | 3.950 | 4.036 | 2.59 | 64.2 |
| TOT-N | 80 | 0.670 | 43.635 | 5.428 | 5.753 | 5.07 | 88.2 |
| SOL-N | 80 | 0.550 | 9.695 | 4.605 | 4.407 | 2.35 | 53.4 |
| F-P | 80 | 0.003 | 0.482 | 0.017 | 0.048 | 0.08 | 159.7 |
| TOT-P | 78 | 0.006 | 3.210 | 0.138 | 0.306 | 0.51 | 166.5 |
| SOL-P | 77 | 0.007 | 0.550 | 0.050 | 0.075 | 0.09 | 119.6 |
| STAGE | 75 | 9.800 | 12.400 | 11.900 | 11.727 | 0.53 | 4.5 |

## Table 7.2 Water Quality Data for Grab Samples Obtained from Sites 4, 5, and 6

Site No. 4 (149 samples; 3-19-73 to 12-29-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 75 | 7.000 | 1192.000 | 106.000 | 188.168 | 234.52 | 124.6 |
| NH4-N | 74 | 0.025 | 2.340 | 0.320 | 0.454 | 0.47 | 104.3 |
| NO3-N | 74 | 0.070 | 13.080 | 4.043 | 4.222 | 2.50 | 59.2 |
| TOT-N | 73 | 0.560 | 14.715 | 5.305 | 5.715 | 3.01 | 52.7 |
| SOL-N | 75 | 0.290 | 9.890 | 4.320 | 4.514 | 2.40 | 53.1 |
| F-P | 75 | 0.001 | 0.287 | 0.018 | 0.037 | 0.05 | 130.7 |
| TOT-P | 71 | 0.003 | 2.490 | 0.130 | 0.291 | 0.42 | 144.6 |
| SOL-P | 70 | 0.009 | 0.326 | 0.054 | 0.070 | 0.06 | 86.4 |
| STAGE | 70 | 6.000 | 9.700 | 8.100 | 7.960 | 0.56 | 7.1 |

Site No. 5 (153 samples; 3-19-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 77 | 14.000 | 1594.500 | 125.500 | 249.252 | 312.54 | 125.4 |
| NH4-N | 76 | 0.025 | 11.810 | 0.513 | 1.040 | 1.68 | 161.6 |
| NO3-N | 78 | 0.284 | 12.885 | 5.200 | 5.264 | 2.78 | 52.9 |
| TOT-N | 78 | 2.205 | 24.290 | 6.618 | 7.382 | 3.72 | 50.3 |
| SOL-N | 78 | 1.520 | 15.270 | 5.883 | 6.189 | 2.80 | 45.3 |
| F-P | 78 | 0.022 | 1.145 | 0.092 | 0.198 | 0.24 | 122.4 |
| TOT-P | 78 | 0.064 | 2.780 | 0.435 | 0.621 | 0.53 | 86.0 |
| SOL-P | 78 | 0.026 | 1.777 | 0.137 | 0.273 | 0.34 | 125.0 |
| STAGE | 74 | 2.900 | 5.500 | 4.600 | 4.629 | 0.55 | 11.8 |

Site No. 6 (147 samples; 3-27-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 74 | 5.000 | 1879.500 | 129.250 | 244.233 | 307.79 | 126.0 |
| HN4-N | 73 | 0.025 | 6.328 | 0.500 | 0.874 | 1.21 | 138.5 |
| NO3-N | 73 | 0.170 | 12.720 | 3.900 | 3.906 | 2.20 | 56.3 |
| TOT-N | 74 | 1.210 | 13.283 | 6.028 | 6.155 | 2.55 | 41.5 |
| SOL-N | 74 | 1.000 | 12.280 | 4.655 | 4.876 | 2.07 | 42.5 |
| F-P | 74 | 0.015 | 1.783 | 0.105 | 0.160 | 0.22 | 139.8 |
| TOT-P | 73 | 0.115 | 3.835 | 0.436 | 0.628 | 0.64 | 101.6 |
| SOL-P | 74 | 0.026 | 1.924 | 0.164 | 0.208 | 0.24 | 116.9 |
| STAGE | 72 | 8.750 | 11.600 | 11.200 | 11.051 | 0.57 | 5.2 |

## Table 7.3 Water Quality Data for Grab Samples Obtained from Sites 7, 8, and 9

Site No. 7 (91 samples; 4-18-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 44 | 24.000 | 926.500 | 103.750 | 167.032 | 177.53 | 106.3 |
| NH4-N | 45 | 0.060 | 1.540 | 0.210 | 0.340 | 0.33 | 98.1 |
| NO3-N | 45 | 0.400 | 14.250 | 5.603 | 5.717 | 3.52 | 61.6 |
| TOT-N | 45 | 1.505 | 16.370 | 6.840 | 7.105 | 3.73 | 52.5 |
| SOL-N | 45 | 0.763 | 14.015 | 5.065 | 5.880 | 3.31 | 56.2 |
| F-P | 45 | 0.005 | 0.146 | 0.028 | 0.039 | 0.03 | 87.8 |
| TOT-P | 45 | 0.017 | 2.425 | 0.162 | 0.340 | 0.48 | 141.0 |
| SOL-P | 45 | 0.003 | 0.780 | 0.061 | 0.102 | 0.13 | 131.1 |
| STAGE | 44 | 2.000 | 3.400 | 3.000 | 2.949 | 0.30 | 10.1 |

Site No. 8 (149 samples; 3-27-73 to 12-24-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 68 | 32.000 | 1291.000 | 108.500 | 182.433 | 222.57 | 122.0 |
| NH4-N | 68 | 0.021 | 1.485 | 0.285 | 0.394 | 0.32 | 81.7 |
| NO3-N | 68 | 0.065 | 13.490 | 2.228 | 2.735 | 2.23 | 81.6 |
| TOT-N | 69 | 0.805 | 16.270 | 3.640 | 4.516 | 2.87 | 63.6 |
| SOL-N | 69 | 0.045 | 11.085 | 2.835 | 3.304 | 1.97 | 59.6 |
| F-P | 69 | 0.002 | 0.470 | 0.033 | 0.072 | 0.09 | 127.1 |
| TOT-P | 68 | 0.016 | 2.265 | 0.199 | 0.372 | 0.45 | 122.2 |
| SOL-P | 65 | 0.008 | 1.500 | 0.067 | 0.130 | 0.21 | 157.8 |
| STAGE | 67 | 6.000 | 13.400 | 12.400 | 10.918 | 2.53 | 23.2 |

Site No. 9 (139 samples; 4-18-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 70 | 11.000 | 1773.500 | 127.500 | 225.641 | 327.73 | 145.2 |
| NH4-N | 72 | 0.025 | 3.855 | 0.398 | 0.724 | 0.79 | 109.4 |
| NO3-N | 72 | 0.390 | 18.540 | 3.288 | 3.749 | 3.17 | 84.5 |
| TOT-N | 71 | 2.245 | 20.990 | 5.180 | 5.875 | 3.20 | 54.5 |
| SOL-N | 71 | 1.740 | 15.990 | 4.275 | 4.774 | 2.55 | 53.3 |
| F-P | 72 | 0.013 | 0.981 | 0.150 | 0.201 | 0.18 | 87.6 |
| TOT-P | 71 | 0.088 | 3.598 | 0.420 | 0.643 | 0.59 | 91.1 |
| SOL-P | 71 | 0.041 | 3.212 | 0.200 | 0.336 | 0.47 | 139.9 |
| STAGE | 71 | 4.000 | 8.900 | 5.900 | 5.913 | 0.69 | 11.7 |

**Table 7.4 Water Quality Data for Grab Samples Obtained from Sites 10, 11, and 12**

Site No. 10 (144 samples; 4-18-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 73 | 33.500 | 1868.500 | 115.000 | 219.503 | 313.35 | 142.8 |
| NH4-N | 71 | 0.025 | 29.350 | 0.880 | 2.861 | 5.29 | 184.9 |
| NO3-N | 71 | 0.140 | 15.455 | 3.340 | 3.874 | 2.85 | 73.6 |
| TOT-N | 71 | 0.215 | 74.860 | 6.640 | 8.842 | 9.75 | 110.2 |
| SOL-N | 72 | 0.230 | 32.580 | 5.483 | 6.655 | 5.35 | 80.4 |
| F-P | 73 | 0.071 | 11.500 | 0.270 | 0.768 | 1.61 | 209.0 |
| TOT-P | 70 | 0.016 | 18.100 | 0.770 | 1.404 | 2.31 | 164.9 |
| SOL-P | 73 | 0.100 | 12.500 | 0.335 | 1.016 | 2.18 | 214.4 |
| STAGE | 69 | 10.250 | 14.300 | 13.700 | 13.540 | 0.59 | 4.3 |

Site No. 11 (122 samples; 3-27-73 to 12-24-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 66 | 8.000 | 1231.500 | 114.500 | 156.436 | 181.25 | 115.9 |
| NH4-N | 64 | 0.025 | 1.040 | 0.258 | 0.316 | 0.21 | 67.7 |
| NO3-N | 65 | 0.290 | 17.695 | 6.660 | 7.132 | 4.17 | 58.5 |
| TOT-N | 66 | 1.500 | 18.240 | 7.708 | 7.652 | 3.62 | 47.3 |
| SOL-N | 66 | 1.250 | 12.905 | 6.510 | 6.683 | 3.28 | 49.2 |
| F-P | 66 | 0.005 | 0.130 | 0.029 | 0.037 | 0.03 | 80.0 |
| TOT-P | 65 | 0.020 | 2.515 | 0.190 | 0.276 | 0.37 | 135.3 |
| SOL-P | 64 | 0.007 | 0.403 | 0.063 | 0.074 | 0.06 | 82.4 |
| STAGE | 65 | 2.500 | 12.100 | 7.100 | 6.994 | 2.31 | 33.1 |

Site No. 12 (150 samples; 3-25-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 76 | 12.000 | 1221.500 | 114.750 | 184.188 | 223.80 | 121.5 |
| NH4-N | 72 | 0.025 | 1.820 | 0.258 | 0.405 | 0.38 | 94.2 |
| NO3-N | 72 | 0.045 | 12.355 | 5.070 | 5.016 | 3.13 | 62.5 |
| TOT-N | 76 | 0.730 | 14.040 | 6.205 | 5.978 | 3.20 | 53.5 |
| SOL-N | 76 | 0.290 | 13.050 | 4.928 | 5.096 | 3.00 | 58.9 |
| F-P | 75 | 0.004 | 0.916 | 0.029 | 0.063 | 0.12 | 197.5 |
| TOT-P | 75 | 0.008 | 2.510 | 0.192 | 0.364 | 0.51 | 139.8 |
| SOL-P | 72 | 0.004 | 6.513 | 0.066 | 0.184 | 0.77 | 418.2 |
| STAGE | 75 | 1.300 | 14.200 | 12.100 | 10.984 | 2.69 | 24.5 |

**Table 7.5 Water Quality Data for Grab Samples Obtained from Sites 13 and 14**

Site No. 13 (158 samples: 4-18-73 to 12-24-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 83 | 12.000 | 1763.000 | 109.000 | 232.178 | 352.87 | 152.0 |
| NH4-N | 83 | 0.025 | 2.085 | 0.205 | 0.280 | 0.32 | 114.2 |
| NO3-N | 82 | 0.040 | 12.995 | 3.915 | 4.105 | 2.83 | 69.0 |
| TOT-N | 83 | 0.570 | 19.680 | 5.095 | 5.176 | 3.22 | 62.3 |
| SOL-N | 82 | 0.130 | 11.450 | 4.443 | 4.427 | 2.58 | 58.3 |
| F-P | 81 | 0.001 | 0.122 | 0.012 | 0.018 | 0.02 | 107.3 |
| TOT-P | 78 | 0.020 | 1.860 | 0.102 | 0.227 | 0.33 | 143.4 |
| SOL-P | 77 | 0.007 | 0.380 | 0.033 | 0.046 | 0.05 | 110.5 |
| STAGE | 81 | 5.600 | 9.900 | 9.100 | 8.985 | 0.80 | 8.9 |

Site No. 14 (124 samples: 3-25-73 to 12-16-74) mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 65 | 9.000 | 534.000 | 126.500 | 145.790 | 112.14 | 76.9 |
| NH4-N | 64 | 0.070 | 1.900 | 0.233 | 0.374 | 0.39 | 103.1 |
| NO3-N | 65 | 0.835 | 8.945 | 2.955 | 3.296 | 1.54 | 46.8 |
| TOT-N | 65 | 1.750 | 11.180 | 4.420 | 4.785 | 1.85 | 38.7 |
| SOL-N | 65 | 0.975 | 8.100 | 3.675 | 3.340 | 1.42 | 37.0 |
| F-P | 65 | 0.036 | 0.376 | 0.073 | 0.106 | 0.08 | 73.8 |
| TOT-P | 65 | 0.159 | 1.643 | 0.358 | 0.401 | 0.23 | 56.3 |
| SOL-P | 65 | 0.038 | 0.440 | 0.106 | 0.139 | 0.09 | 62.4 |
| STAGE | 63 | 15.200 | 32.900 | 29.000 | 27.556 | 4.66 | 16.9 |

components. Obviously, all runoff events will result in increased loading of nitrogen and phosphorus components entering the stream even though the concentration may remain essentially constant.

A summary of the median concentrations for solids, nitrogen, and phosphorus components is presented in table 7.6. For the majority of sites, a relatively narrow range of median values is encountered, suggesting that the composition of water is constant throughout the watershed. Inspection of figure 7.1 and table 7.6 indicates four sites in the watershed are influenced by the town of Harlan. These sites are No. 5, 6, 9, and 10. Table 7.7 compares the composition of water samples obtained from agricultural and domestic sources with samples from the Maumee River (site 14). The effect of domestic wastes if readily seen in the ammonium, soluble inorganic phosphorus, soluble total phosphorus and particulate phosphorus concentrations. Comparison of the Maumee River and sites draining agricultural areas indicates similar concentrations are found for most water quality parameters. In general, water present in Black Creek and its tributaries contains nitrogen in equal concentrations to that found in the Maumee River but it possesses lower concentrations of phosphorus components. For example, soluble inorganic phosphorus in the Mau-

### Table 7.6 Median Concentration of Water Quality Parameters for Grab Samples Obtained from March 19, 1973, to December 29, 1974

| Site | Suspended solids | $NH_4$-N | $NO_3$-N | Soluble N | Particulate N | Soluble Inorg. P | Soluble P | Particulate P |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | | |
| 1 | 129 | 0.25 | 7.44 | 7.02 | 1.42 | 0.041 | 0.064 | 0.117 |
| 2 | 118 | 0.25 | 5.70 | 5.66 | 1.16 | 0.021 | 0.054 | 0.098 |
| 3 | 124 | 0.26 | 3.95 | 4.60 | 0.82 | 0.017 | 0.050 | 0.088 |
| 4 | 106 | 0.32 | 4.04 | 4.32 | 0.98 | 0.018 | 0.054 | 0.076 |
| 5 | 126 | 0.51 | 5.20 | 5.88 | 0.74 | 0.092 | 0.137 | 0.298 |
| 6 | 129 | 0.50 | 3.90 | 4.66 | 1.37 | 0.105 | 0.164 | 0.272 |
| 7 | 104 | 0.21 | 5.60 | 5.86 | 0.98 | 0.028 | 0.061 | 0.101 |
| 8 | 108 | 0.28 | 2.23 | 2.84 | 0.80 | 0.033 | 0.067 | 0.132 |
| 9 | 128 | 0.40 | 3.29 | 4.28 | 0.90 | 0.150 | 0.200 | 0.220 |
| 10 | 115 | 0.88 | 3.34 | 5.48 | 1.16 | 0.270 | 0.335 | 0.435 |
| 11 | 114 | 0.26 | 6.66 | 6.51 | 1.28 | 0.029 | 0.063 | 0.127 |
| 12 | 115 | 0.26 | 5.07 | 4.93 | 1.28 | 0.029 | 0.066 | 0.126 |
| 13 | 109 | 0.20 | 3.92 | 4.44 | 0.65 | 0.012 | 0.033 | 0.069 |
| 14 | 126 | 0.23 | 2.96 | 3.68 | 0.74 | 0.073 | 0.106 | 0.252 |

Table 7.7 Comparison of Median Concentrations for Sampling Sites Influenced by Domestic and Agricultural Activities with Concentrations in the Maumee River

| Component | Maumee River[1] | Type of activity influencing site[1] | |
|---|---|---|---|
| | | Domestic[2] | Agricultural[3] |
| | | mg/1 | |
| Suspended solids | 126 | 115-128 | 106-129 |
| $NH_4$-N | 0.23 | 0.40-0.88 | 0.20-0.32 |
| $NO_3$-N | 2.96 | 3.29-5.20 | 2.23-7.44 |
| Soluble N | 3.68 | 4.28-5.88 | 2.84-7.02 |
| Particulate N | 0.74 | 0.90-1.37 | 0.65-1.42 |
| Soluble inorg. P | 0.073 | 0.092-0.270 | 0.012-0.041 |
| Soluble P | 0.106 | 0.137-0.335 | 0.033-0.067 |
| Particulate P | 0.252 | 0.220-0.435 | 0.069-0.132 |

[1] Site 14

[2] Sites 5, 6, 9 and 10

[3] Sites 1, 2, 3, 4, 7, 8, 11, 12 and 13

mee is 0.073 mg/1,whereas water samples obtained from the watershed range from 0.012 to 0.041 mg/1. Similar trends are seen for total soluble and particulate phosphorus.

The distribution between soluble and particulate forms of nitrogen and phosphorus is similar for watershed and Maumee River samples (tables 7.8). Of the total present, 83 percent and 32 percent of the nitrogen and phosphorus, respectively, are found in soluble species. This arises from the solubility of nitrogen (i.e., nitrate) and the insolubility of phosphorus. Thus, most of the phosphorus leaving the watershed is attached to soil material eroded from the landscape. These data emphasize the importance of measuring both soluble and total nutrients in water samples. It should be noted that the distribution between particulate and soluble forms of nitrogen and phosphorus are essentially the same for the Maumee River and the average of all the sites sampled in the watershed.

**Table 7.8 Proportion of Nitrogen and Phosphorus Present in Water Samples as Particulate and Soluble Components**

| Site | Soluble | | Particulate | |
|---|---|---|---|---|
| | N | P | N | P |
| | % of total | | | |
| 1 | 83 | 35 | 17 | 65 |
| 2 | 83 | 36 | 17 | 64 |
| 3 | 85 | 36 | 15 | 64 |
| 4 | 82 | 42 | 18 | 58 |
| 5 | 89 | 32 | 11 | 68 |
| 6 | 77 | 38 | 23 | 62 |
| 7 | 86 | 38 | 14 | 62 |
| 8 | 78 | 34 | 22 | 66 |
| 9 | 83 | 48 | 17 | 52 |
| 10 | 82 | 44 | 18 | 56 |
| 11 | 84 | 33 | 16 | 67 |
| 12 | 79 | 34 | 21 | 66 |
| 13 | 87 | 32 | 13 | 68 |
| Average | 83 | 32 | 17 | 68 |
| Maumee River | 83 | 30 | 17 | 70 |

## B. Pump Samples

Detailed analysis of 3 storm events are possible using the samples obtained from the pump samplers. The following events were monitored: site 2, February 2, 1975; site 2, March 7, 1975; site 2, March 17, 1975; site 6, March 17, 1975. As mentioned previously, the samplers are located in the lower portion of the watershed and thus, should give information concerning the forms and amounts of nutrients entering the Maumee River from the watershed. Three figures have been prepared for each event — the first presenting flow, solids and phosphorus components, the second presenting flow, solids and nitrogen componenets, the third presenting flow and loading of solids, nitrogen and phosphorus (figures 7.2 to 7.13). In general, the relationships between concentration and time indicate that soluble components, (i.e., nitrate, soluble inorganic phosphorus, soluble total phosphorus, soluble total nitrogen) are relatively constant throughout an event. In contrast, the concentration

**Table 7.9 Statistical Analysis of Water Quality Data for Three Storm Events Occurring at Site 2**

44 samples; 2-22-75 and 2-23-75 mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 44 | 109.000 | 1118.000 | 508.000 | 547.341 | 202.71 | 37.0 |
| NH4-N | 44 | 0.210 | 1.680 | 0.580 | 0.696 | 0.36 | 52.0 |
| NO3-N | 44 | 4.880 | 10.900 | 8.440 | 8.278 | 1.44 | 17.4 |
| TOT-N | 44 | 7.810 | 31.660 | 13.000 | 14.910 | 5.29 | 35.5 |
| SOL-N | 44 | 5.500 | 11.480 | 9.725 | 9.531 | 1.38 | 14.5 |
| F-P | 44 | 0.017 | 0.109 | 0.046 | 0.044 | 0.02 | 36.3 |
| TOT-P | 44 | 0.432 | 4.220 | 1.163 | 1.498 | 1.06 | 70.8 |
| SOL-P | 44 | 0.050 | 0.108 | 0.080 | 0.080 | 0.02 | 19.7 |
| STAGE | 44 | 1.250 | 4.080 | 2.490 | 2.767 | 0.92 | 33.1 |

39 samples; 3-7-75 and 3-8-75 mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 39 | 101.000 | 712.000 | 218.000 | 288.256 | 173.96 | 60.3 |
| NH4-N | 39 | 0.160 | 2.150 | 0.630 | 0.799 | 0.49 | 61.9 |
| NO3-N | 39 | 6.130 | 10.170 | 8.700 | 8.541 | 1.09 | 12.8 |
| TOT-N | 39 | 7.760 | 17.250 | 11.480 | 11.712 | 1.63 | 13.9 |
| SOL-N | 39 | 7.760 | 11.110 | 10.070 | 9.819 | 0.94 | 9.6 |
| F-P | 39 | 0.012 | 0.051 | 0.026 | 0.030 | 0.01 | 39.5 |
| TOT-P | 39 | 0.164 | 1.008 | 0.340 | 0.399 | 0.21 | 51.5 |
| SOL-P | 39 | 0.017 | 0.111 | 0.055 | 0.053 | 0.02 | 38.7 |
| STAGE | 39 | 1.080 | 1.830 | 1.450 | 1.449 | 0.26 | 17.7 |

64 samples; 3-17-75 to 3-19-75 mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 64 | 72.000 | 332.000 | 125.500 | 151.672 | 68.34 | 45.1 |
| HN4-N | 64 | 0.100 | 1.630 | 0.370 | 0.485 | 0.29 | 59.3 |
| NO3-N | 64 | 3.620 | 10.220 | 9.490 | 8.982 | 1.34 | 14.9 |
| TOT-N | 64 | 5.450 | 21.760 | 11.195 | 11.093 | 1.72 | 15.5 |
| SOL-N | 64 | 4.560 | 21.760 | 10.540 | 10.214 | 1.96 | 19.2 |
| F-P | 64 | 0.013 | 0.037 | 0.025 | 0.025 | 0.01 | 21.9 |
| TOT-P | 64 | 0.146 | 1.266 | 0.213 | 0.272 | 0.17 | 62.9 |
| SOL-P | 64 | 0.018 | 0.081 | 0.059 | 0.058 | 0.01 | 23.1 |
| STAGE | 64 | 0.900 | 1.320 | 1.060 | 1.082 | 0.10 | 9.0 |

## Table 7.10 Statistical Analysis of Water Quality Data for One Storm Event Occuring at Site 6

50 samples; 3-17-75 to 3-19-75 mg/l

| COMPONENT | N | MIN | MAX | MEDIAN | MEAN | S D | C V |
|---|---|---|---|---|---|---|---|
| SUS-S | 50 | 111.000 | 2060.000 | 314.500 | 457.920 | 429.13 | 93.7 |
| NH4-N | 50 | 0.310 | 1.050 | 0.580 | 0.582 | 0.14 | 23.3 |
| NO3-N | 50 | 4.090 | 8.750 | 7.315 | 6.998 | 1.15 | 16.5 |
| TOT-N | 50 | 6.820 | 21.130 | 11.085 | 11.953 | 2.81 | 23.5 |
| SOL-N | 50 | 4.140 | 10.220 | 8.910 | 8.511 | 1.23 | 14.4 |
| F-P | 50 | 0.020 | 0.184 | 0.137 | 0.137 | 0.03 | 21.4 |
| TOT-P | 50 | 0.182 | 2.230 | 0.620 | 0.738 | 0.42 | 57.0 |
| SOL-P | 50 | 0.045 | 0.376 | 0.186 | 0.187 | 0.04 | 22.1 |
| STAGE | 50 | 0.730 | 1.500 | 1.075 | 1.051 | 0.19 | 17.9 |

## Table 7.11 Characteristics of Soils Used in the Investigation

| Characteristic† | Soil Type* | | | |
|---|---|---|---|---|
| | Haskins l | Nappanee | Morley cl | Hoytville sic |
| Slope, % | 0.1-0.3% | 0.7-0.8% | 4.7-5.2% | 0.3-0.7% |
| Clay, % | 12.5 | 29.5 | 33.0 | 43.8 |
| Silt, % | 44.5 | 41.5 | 43.5 | 42.0 |
| Sand, % | 43.0 | 28.9 | 23.5 | 14.2 |
| Total N, ppm | 1021 | 1557 | 1240 | 2969 |
| Total P, ppm | 363 | 706 | 366 | 1364 |
| Ext. P, ppm | 46 | 44 | 12 | 116 |
| EPC, ppb | 50 | 45 | 21 | 115 |

*l, loam; cl, clay loam; sic silty clay

† slope is average slope of experimental area; ext. P is amount of dilute acid soluble P (Bray $P_1$) in soil.

of total nitrogen and phosphorus, which are present in the particulate phase of runoff, tend to parallel the suspended solids and flow. Thus, total phosphorus, nitrogen and solids loadings yield a family of nearly parallel curves.

The minimum, maximum, median, mean, standard deviation and CV for each event are presented in tables 7.9 and 7.10. The magnitude of the variations in chemical composition of water during an event is apparent in these data.

## 5. EVALUATION OF FERTILIZER LOSS USING THE RAINFALL SIMULATOR

### A. Rainulator Studies

The rainfall simulator was used to evaluate the loss of fertilizer and native soil nitrogen and phosphorus from four soil types found in the Black Creek watershed. The characteristics of the four soils used are shown in table 7.11. All plots were disked once at right angles to the slope and once up and down slope. Two plots of each soil type were fertilized with 50 lbs. phosphorus/ac (56 kg/ha) of triple superphosphate and 150 lbs. nitrogen/ac (168 kg/ha) as ammonium nitrate. Rainstorms were applied at an intensity of 2.50 in/hr (6.35 cm/hr). Two rainstorms were applied to the larger plots, one of 60 minute duration and one of 30 minute duration. The small plots had one storm applied of 45 minute duration.

The treatment conditions in this study are very severe and should reveal the losses of nutrients under the worst possible conditions for nutrient loss. High rates of nitrogen and phosphorus fertilizer were applied to the surface of the soil just prior to the initiation of a 2.50 in/hr (6.35 cm/hr) rainstorm. This type of situation presents the greatest potential for nutrient loss in runoff water.

The runoff losses of phosphorus and solids are shown in table 7.12 and the losses of nitrogen are shown in table 7.13. The losses of soil and nutrients were low from these gently sloping soils as compared with losses reported for other rainulator studies. It has been shown previously that soil losses of 9.4 and 11 tons/ac (21.38 and 24.74 tons/ha) resulted from two successive storms applied to a conventionally tilled Bedford silt loam on a 8.3 percent and 12.4 percent slope. Soil losses from rainstorms applied to the soils in this study ranged from .07 (.15) for the nearly level Nappanee clay loam to .97 tons (2.18t) for the Morley clay loam soil having 5 percent slope. Soil losses were probably low because of the higher clay content and reduced slope of these soils as compared to the Bedford soil. The sediment nitrogen and phosphorus losses were lower than or equal to those found on the Bedford silt loam. Sediment phosphorus losses on the Bedford soil were 6.7 to 10 lbs/ac (7.52 to 11.25 kg/ha) as compared to .39 to 5.3 lbs/ac (.38 to 5.90 kg/ha) for soils in this study. Sediment nitrogen losses were also less for the soils representative of the Maumee River basin 1.4 to 22 lbs/ac (1.52 to 24.22 kg/ha) as compared to 19 to 26 lbs/ac (21.84 to 28.59 kg/ha) for the Bedford silt loam. Since the sediment losses from the Bedford soil were high, it is logical that sediment nutrient losses should also be greater. Plowing down fertilizers on Bedford silt loam reduced the losses of soluble nitrogen and phosphorus to levels equal or lower than the four soils used in this study. The concentration of soluble inorganic phosphorus was reduced the most by incorporation; however, the concentrations of nitrate and ammonium were also reduced markedly by plowing. Even through surface application of fertilizer without incorporation increases the loss of soluble nitrogen and phosphorus, nutrient losses when expressed as a percentage of fertilizer applied remain quite low.

### Table 7.12 Losses of Soil and Phosphorus Components in Surface Runoff from Fertilized (F) and Unfertilized (U) Plots of Four Soil Types (Haskins, Nappanee, Hoytville, Morley)

| Rainstorm No. | Storm duration | Treatment | Total runoff | Solids runoff | Soil inorg. P | Sol. org. P | Sed. P | Σ of P forms |
|---|---|---|---|---|---|---|---|---|
| | min. | | tons/ha | ← kg/ha → | | | | |
| | | | | Haskins loam | | | | |
| 1 | 60 | U | 305 | 2280 | 0.019 | 0.017 | 2.410 | 2.446 |
| | 60 | F | 368 | 2050 | 0.302 | 0.125 | 2.910 | 3.337 |
| 1 | 45 | U | 227 | 1250 | 0.017 | 0.011 | 1.340 | 1.368 |
| | 45 | F | 245 | 1000 | 0.400 | 0.000 | 2.490 | 2.890 |
| 2 | 30 | U | 239 | 1240 | 0.021 | 0.012 | 1.060 | 1.093 |
| | 30 | F | 264 | 1170 | 0.115 | 0.008 | 1.200 | 1.323 |
| | | | | Nappanee clay loam | | | | |
| 1 | 60 | U | 168 | 320 | 0.013 | 0.003 | 0.380 | 0.306 |
| | 60 | F | 210 | 415 | 0.140 | 0.015 | 0.884 | 1.039 |
| 1 | 45 | U | 172 | 730 | 0.015 | 0.002 | 0.728 | 0.745 |
| | 45 | F | 151 | 310 | 0.250 | 0.004 | 1.458 | 1.712 |
| 2 | 30 | U | 195 | 290 | 0.012 | 0.011 | 0.379 | 0.402 |
| | 30 | F | 251 | 770 | 0.051 | 0.013 | 0.931 | 0.995 |
| | | | | Hoytville silty clay | | | | |
| 1 | 60 | U | 253 | 410 | 0.054 | 0.030 | 0.822 | 0.906 |
| | 60 | F | 233 | 780 | 0.206 | 0.020 | 1.594 | 1.820 |
| 1 | 45 | U | 206 | 280 | 0.052 | 0.000 | 1.409 | 1.461 |
| | 45 | F | 162 | 700 | 0.165 | 0.036 | 1.396 | 1.597 |
| 2 | 30 | U | 256 | 680 | 0.049 | 0.011 | 1.378 | 1.438 |
| | 30 | F | 283 | 880 | 0.088 | 0.010 | 1.991 | 2.089 |
| | | | | Morley clay loam | | | | |
| 1 | 60 | U | 395 | 3940 | 0.004 | 0.012 | 2.713 | 2.729 |
| | 60 | F | 389 | 4380 | 0.115 | 0.020 | 5.905 | 6.040 |
| 1 | 45 | U | 234 | 1990 | 0.004 | 0.006 | 1.917 | 1.927 |
| | 45 | F | 203 | 1420 | 0.175 | 0.000 | 2.255 | 2.430 |
| 2 | 30 | U | 280 | 3190 | 0.003 | 0.005 | 2.208 | 2.216 |
| | 30 | F | 289 | 3700 | 0.056 | 0.001 | 3.337 | 3.394 |

Table 7.13 Losses of Nitrogen Components in Surface Runoff from Fertilized (F) and Unfertilized (U) Plots of Four Soil Types

| Rainstorm No. | Storm duration | Treatment | $NH_4^+$-N | $NO_3^-$-N | Sol. Org. N | Sed. N | $\Sigma$ of N forms |
|---|---|---|---|---|---|---|---|
| | | | kg/ha | | | | |
| | | | Haskins loam | | | | |
| 1 | 60 | U | 0.067 | 0.706 | 0.088 | 5.270 | 6.131 |
| | 60 | F | 0.510 | 0.547 | 0.270 | 5.420 | 6.747 |
| 1 | 45 | U | 0.051 | 0.714 | 0.000 | 3.650 | 4.415 |
| | 45 | F | 0.750 | 0.750 | 0.000 | 2.690 | 4.441 |
| 2 | 30 | U | 0.091 | 0.091 | 0.248 | 3.026 | 3.539 |
| | 30 | F | 0.547 | 0.258 | 0.193 | 3.200 | 4.206 |
| | | | Nappanee clay loam | | | | |
| 1 | 60 | U | 0.030 | 0.198 | 0.092 | 1.700 | 2.020 |
| | 60 | F | 0.863 | 0.295 | 0.353 | 4.130 | 5.640 |
| 1 | 45 | U | 0.880 | 0.298 | 0.000 | 1.520 | 1.906 |
| | 45 | F | 0.607 | 0.864 | 0.000 | 3.100 | 4.571 |
| 2 | 30 | U | 0.023 | 0.074 | 0.131 | 1.310 | 1.538 |
| | 30 | F | 0.810 | 0.732 | 0.000 | 3.670 | 5.212 |
| | | | Hoytville silty clay | | | | |
| 1 | 60 | U | 0.054 | 1.708 | 0.000 | 3.850 | 5.612 |
| | 60 | F | 0.863 | 3.027 | 0.048 | 3.780 | 7.718 |
| 1 | 45 | U | 0.051 | 0.350 | 0.086 | 2.980 | 3.467 |
| | 45 | F | 0.607 | 4.930 | 0.000 | 3.920 | 9.457 |
| 2 | 30 | U | 0.023 | 0.340 | 0.033 | 3.950 | 4.346 |
| | 30 | F | 0.810 | 0.546 | 0.000 | 5.430 | 7.596 |
| | | | Morley clay loam | | | | |
| 1 | 60 | U | 0.107 | 0.367 | 0.024 | 20.090 | 20.588 |
| | 60 | F | 1.629 | 0.777 | 0.000 | 24.220 | 26.626 |
| 1 | 45 | U | 0.029 | 0.159 | 0.169 | 10.620 | 10.977 |
| | 45 | F | 0.628 | 0.463 | 0.015 | 7.910 | 9.016 |
| 2 | 30 | U | 0.066 | 0.348 | 0.000 | 11.370 | 11.784 |
| | 30 | F | 1.407 | 0.725 | 0.266 | 13.320 | 15.718 |

It is evident from looking at the results that fertilizer application does lead to increased nutrient loss from soils. The increases are the greatest in the soluble nitrate, ammonium and inorganic phosphorus fractions. Sediment phosphorus also appears to increase with fertilizer addition probably as a result of sorption of added inorganic phosphorus by the clay fraction in soil. The loss of sediment nitrogen does not seem to be markedly affected by fertilization.

The percent of the various types of nitrogen and phosphorus found in the runoff as compared to the total amounts of nitrogen and phosphorus in runoff is listed in table 7.14. In unfertilized plots the large majority of the nitrogen found in runoff is in the sediment. On the contrary, with fertilized plots the proportion of sediment nitrogen in runoff decreased as the ammonium-nitrogen and nitrate-nitrogen originating from fertilizer increased. However, the fraction of sediment nitrogen in fertilized plot runoff was at least 41 percent and in most cases greater than 50 percent of the total nitrogen. In unfertilized plots, almost all the phosphorus in runoff is sediment phosphorus. When plots are fertilized the percentage of total phosphorus in runoff present as sediment phosphorus decreases but stays at relatively high levels. Data from the fertilized plots reveals that at least 85 percent of the total phosphorus in runoff was in the sediment phase.

From the above data it can be concluded that the most effective way to control loss of phosphorus and to a lesser extent nitrogen is to control soil erosion. Substantial decreases in the total nutrient load would have occurred if soil erosion were decreased. Most likely the amounts of soluble nitrogen and phosphorus in runoff would decrease if the fertilizer were incorporated in a way that would also minimize erosion.

The majority of soluble inorganic nitrogen and inorganic phosphorus in runoff is derived from fertilizer (table 7.15). In most cases the majority of sediment nitrogen is derived from the soil. The Nappanee clay loam was an exception since the sediment nitrogen derived from fertilizer sources was quite high. This finding may be due to the high clay content of the soil which would increase the probability of large amounts of added ammonium present on the exchange sites of the eroded soil. Substantial proportion of the sediment phosphorus appears to be derived from the added fertilizer. This finding is further substantiated by the increased concentration of phosphorus in the sediment from fertilized plots as compared to sediment from unfertilized plots. The increases in sediment phosphorus and nitrogen in runoff resulting from fertilizer are apparently due to the attachment of ammonium to cation exchange sites and the sorption of phosphate to the clay mineral surfaces shortly after fertilization. These nutrients are then carried from the plots as components of the sediment during erosion.

Total inorganic nitrogen removed in runoff from the two storms varied from 0.4 percent to 2.2 percent of that applied (table 7.16). Losses of applied inorganic nitrogen from Haskins soil were substantially lower than the other three soils. This finding may have been due to the high infiltration rate in Haskins soil because of higher amounts of sand and lower clay content than other solid thus permitting ammonium and nitrate to be moved deeper into the soil making it less susceptible to runoff. The amount of fertilizer nitrogen lost in all forms varied from 0.8 percent to 5.9 percent of that added (table 7.16). The losses of added nitrogen from Haskins soil again were much lower than other soils which seems to indicate the clay content of the soil may be the difference since the fertilizer nitrogen lost in the sediment phase was probably largely in the form of ammonium on the cation exchange sites.

The percentages of soluble inorganic phosphorus removal by runoff water varied from 0.3 percent to 0.7 percent of that added and the amount of added phosphorus lost in all forms in runoff varied from 2.0 percent to 8.0 percent (table 7.16). The losses of fertilizer phosphorus were larger than nitrogen losses as compared to the amounts of fertilizer nitrogen and phosphorus applied. The greater losses of applied phosphorus are apparently from the phosphate sorbed on soil surfaces since the largest amount of phosphorus in runoff is carried by the sediment. The quantities of fertilizer nutrients lost in runoff from the four soils do not represent significant monetary losses to the farmer. The nutrient losses are low considering the severity of the experimental conditions. The incorporation of the fertilizer would have likely substantially reduced losses.

The average concentrations of sediment phosphorus and extractable sediment phosphorus in runoff increased as a result of fertilization (table 7.17). Addition of superphosphate decreased the proportion of total phosphorus in runoff present as sediment phosphorus from 96.6 percent to 91.8 percent. On the average, the total phosphorus content of the sediment increased 269 ppm and the extractable phosphorus content of the sediment increased 97 ppm as a result of fertilization. Superphosphate addition increased the proportion of sediment phosphorus which was extractable with the Bray P1 solution from 20.6 percent to 25.2 percent suggesting that a higher percentage of added phosphorus associated with the sediment was extractable than native phosphorus associated with the sediment. The finding that in excess of 90 percent of the total phosphorus in runoff is sediment phosphorus agrees with previous work and suggests that control of soil erosion can greatly reduce the levels of total phosphorus in surface runoff.

The concentration of sediment nitrogen in runoff was not markedly affected by fertilization although the amount of sediment exchangeable ammonium increased as a result of ammonium nitrate addition. The proportion of total nitrogen in runoff present as sediment nitrogen decreased from 86 percent to 71 percent as a result of fertilization. The fact that sediment nitrogen makes up the bulk of the nitrogen in runoff suggests that control of soil erosion can greatly reduce the total amounts of nitrogen in runoff although the more available soluble nitrogen components would still be present. Fertilization increased the average Kjeldahl nitrogen content of the sediment about 280 ppm and the exchangeable ammonium content about 81 ppm. The proportion of Kjeldahl nitrogen in the sediment present as exchangeable ammonium increased from 1.2 percent to 5 percent with fertilization.

The soluble organic carbon content of runoff averaged 19.6 mg/1 for unfertilized plots and 28.3 mg/1 for fertilized plots. The values are somewhat higher than the soluble organic carbon contents of streams and rivers which are usually about 10 mg/1. The average sediment organic carbon concentration in runoff was about 200 mg/1, thus the organic carbon to Kjeldahl nitrogen ratio (C/N) for surface runoff was approximately 11. Soils normally have a C/N ratio of 9 to 12 so it can be seen that sediment carbon and sediment nitrogen are being eroded in roughly the same proportion that they occur in the soil.

### Table 7.14 Percentage Distribution of the Total Amounts of Nitrogen and Phosphorus in Surface Runoff Among the Nitrogen and Phosphorus Components in Runoff from Fertilized (F) and Unfertilized (U) Plots of Four Soil Types

| Rainstorm No. | Storm duration | Treat-ment | % of total N in runoff as: | | | | % of total P in runoff as: | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $NH_4^+$-N | $NO_3^-$-N | Sol. Org. N | Sed. N | Soil Inorg-P | Sol. Org. P | Sed. P |
| | min | | | | | | | | |
| | | | Haskins loam | | | | | | |
| 1 | 60 | U | 1.1 | 11.5 | 1.4 | 86.0 | 0.8 | 0.7 | 98.5 |
| | 60 | F | 7.6 | 8.1 | 4.0 | 80.3 | 9.1 | 3.8 | 87.2 |
| 1 | 45 | U | 1.1 | 16.2 | 0.0 | 82.7 | 1.3 | 0.8 | 98.0 |
| | 45 | F | 16.9 | 22.5 | 0.0 | 60.6 | 13.8 | 0.0 | 86.2 |
| 2 | 30 | U | 2.6 | 4.9 | 7.0 | 85.5 | 1.9 | 1.1 | 97.2 |
| | 30 | F | 13.0 | 6.1 | 4.6 | 76.1 | 8.7 | 0.6 | 90.7 |
| | | | Nappanee clay loam | | | | | | |
| 1 | 60 | U | 1.5 | 9.8 | 4.5 | 84.2 | 3.2 | 0.8 | 96.0 |
| | 60 | F | 15.3 | 5.2 | 6.3 | 73.2 | 13.5 | 1.4 | 85.1 |
| 1 | 45 | U | 4.6 | 15.6 | 0.0 | 79.7 | 2.0 | 0.3 | 97.7 |
| | 45 | F | 13.2 | 18.9 | 0.0 | 67.8 | 14.6 | 0.2 | 85.2 |
| 2 | 30 | U | 1.5 | 4.8 | 5.5 | 94.9 | 3.0 | 2.7 | 94.3 |
| | 30 | F | 15.5 | 14.0 | 0.0 | 70.4 | 5.1 | 1.3 | 93.6 |
| | | | Hoytville silty clay | | | | | | |
| 1 | 60 | U | 1.0 | 30.4 | 0.0 | 68.6 | 6.0 | 3.3 | 90.7 |
| | 60 | F | 11.2 | 39.2 | 0.6 | 49.0 | 11.3 | 1.1 | 87.6 |
| 1 | 45 | U | 1.5 | 10.1 | 2.5 | 86.0 | 3.6 | 0.0 | 96.4 |
| | 45 | F | 6.4 | 52.1 | 0.0 | 41.5 | 10.3 | 2.2 | 87.4 |
| 2 | 30 | U | 0.5 | 7.8 | 0.8 | 90.9 | 3.6 | 0.8 | 95.8 |
| | 30 | F | 10.7 | 7.2 | 0.0 | 71.5 | 4.2 | 0.5 | 95.3 |
| | | | Morley Clay Loam | | | | | | |
| 1 | 60 | U | 0.5 | 1.8 | 0.1 | 97.6 | 0.1 | 0.4 | 99.4 |
| | 60 | F | 6.1 | 2.9 | 0.0 | 91.0 | 1.9 | 0.3 | 97.8 |
| 1 | 45 | U | 0.3 | 1.4 | 1.5 | 96.7 | 0.2 | 0.3 | 99.5 |
| | 45 | F | 7.0 | 5.1 | 0.2 | 87.7 | 7.2 | 0.0 | 92.8 |
| 2 | 30 | U | 0.6 | 3.0 | 0.0 | 96.5 | 0.1 | 0.2 | 99.6 |
| | 30 | F | 9.0 | 4.6 | 1.7 | 84.7 | 1.6 | 0.0 | 98.3 |

Table 7.15 Percentage of Plant Nutrients in Runoff Water and Sediment from Fertilized Soil Derived from Fertilizer*

| Soil type | Rainstorm No. | Form of N in runoff |  |  | Form of P in runoff |  |  |
|---|---|---|---|---|---|---|---|
|  |  | Sol. Inorg. N | Sed. N | % of all N forms | Sol. Inorg. P | Sed. P | % of all P forms |
|  |  | % of N derived from fertilizer |  |  | % of P derived from fertilizer |  |  |
| Haskins loam | 1 | 26.9 | 2.8 | 9.1 | 93.7 | 17.2 | 26.7 |
|  | 2 | 67.1 | 5.4 | 15.8 | 81.7 | 11.7 | 17.4 |
| Nappanee clay loam | 1 | 80.3 | 58.8 | 64.2 | 90.7 | 57.0 | 61.9 |
|  | 2 | 93.7 | 64.3 | 70.5 | 76.5 | 59.3 | 59.6 |
| Hoytville silty loam | 1 | 54.7 | 0.0 | 27.3 | 73.8 | 48.5 | 50.2 |
|  | 2 | 73.2 | 27.3 | 42.8 | 44.3 | 30.8 | 31.2 |
| Morley clay loam | 1 | 80.3 | 17.1 | 22.7 | 96.5 | 54.1 | 54.8 |
|  | 2 | 80.7 | 14.7 | 25.0 | 94.6 | 33.8 | 34.7 |

*Calculated by subtracting the nutrient loss from the untreated plot from that of the fertilized plot, dividing the difference by the nutrient loss from the fertilized plot, and multiplying the resultant value by 100.

## Table 7.16 Amount of Added Fertilizer Nitrogen and Phosphorus Lost in Runoff from Four Soil Types*

| Soil type | Rainstorm No. | Added N lost in runoff as: |  | Added P lost in runnof as: |  |
|---|---|---|---|---|---|
|  |  | Sol. inorg. N | All N forms | Sol. inorg. P | All P forms |
|  |  | % of added N |  | % of added P |  |
| Haskins loam | 1 | 0.2 | 0.4 | 0.5 | 1.6 |
|  | 2 | 0.2 | 0.4 | 0.2 | 0.4 |
|  |  | 0.4 | 0.8 | 0.7 | 2.0 |
| Nappanee clay loam | 1 | 0.6 | 2.1 | 0.2 | 1.1 |
|  | 2 | 0.9 | 2.1 | 0.1 | 1.1 |
|  |  | 1.5 | 4.2 | 0.3 | 2.2 |
| Hoytville silty clay | 1 | 1.3 | 1.3 | 0.3 | 1.6 |
|  | 2 | 0.6 | 1.9 | 0.1 | 1.2 |
|  |  | 1.9 | 3.2 | 0.4 | 2.8 |
| Morley clay loam | 1 | 1.2 | 3.6 | 0.2 | 5.9 |
|  | 2 | 1.0 | 2.3 | 0.1 | 2.1 |
|  |  | 2.2 | 5.9 | 0.3 | 8.0 |

*Percent of added nutrients lost in runoff was calculated by subtracting the nutrient loss from untreated plots from that of the fertilized plot, dividing the difference by the amount of nutrient added, and multiplying the resultant value by 100.

## Table 7.17 Effect of Fertilization on the Phosphorus, Nitrogen, and Carbon Composition of Sediment in Runoff from Four Soils Subjected to Simulated Rainstorms

| Soil type | Treat-* ment | Rain- storm | Sed. P | Ext. sed. P | Sed. EPC | Sed. total N | Sed. exc. $NH_4$-N | Sed. org. C |
|---|---|---|---|---|---|---|---|---|
| | | | ppm | ppm | ppb P | ppm | ppm | % |
| Haskins | U | 1 | 530 | 76 (14.7) | 28 | 1330 | 46 (3.5) | 0.53 |
| | | 2 | 454 | 65 (14.3) | 35 | 1710 | 47 (2.7) | 1.13 |
| | | 3 | 520 | 94 (18.1) | 30 | 1590 | 60 (3.8) | 1.00 |
| | F | 1 | 643 | 213 (33.1) | 455 | 1750 | 105 (6.0) | 1.18 |
| | | 2 | 685 | 150 (21.9) | 180 | 1610 | 116 (7.2) | 1.00 |
| | | 3 | 661 | 178 (26.9) | 175 | 1620 | 73 (4.5) | 1.46 |
| Nappanee | U | 1 | 267 | 113 (42.3) | 74 | 790 | 0 (0.0) | 3.48 |
| | | 2 | 422 | 153 (36.0) | 44 | 2570 | 0 (0.0) | 3.89 |
| | | 3 | 258 | 127 (49.2) | 44 | 1040 | 0 (0.0) | 3.76 |
| | F | 1 | 547 | 199 (36.4) | 300 | 1840 | 125 (6.8) | 2.50 |
| | | 2 | 707 | 167 (23.6) | 136 | 1830 | 89 (4.9) | 5.11 |
| | | 3 | 828 | 155 (18.7) | 136 | 1590 | 104 (6.5) | 2.64 |
| Morley | U | 1 | 553 | 25 (4.5) | 4 | 1860 | 26 (1.4) | 1.45 |
| | | 2 | 513 | 31 (6.0) | 10 | 1650 | 28 (1.7) | 1.18 |
| | | 3 | 477 | 34 (7.1) | 9 | 1590 | 20 (1.3) | 1.04 |
| | F | 1 | 665 | 196 (29.5) | 104 | 2070 | 95 (4.6) | 1.68 |
| | | 2 | 697 | 146 (20.9) | 54 | 1890 | 100 (4.8) | 1.38 |
| | | 3 | 823 | 161 (19.6) | 48 | 2030 | 80 (3.9) | 2.35 |
| Hoytville | U | 1 | 1230 | 231 (18.8) | 15 | 2350 | 0 (0.0) | 2.13 |
| | | 2 | 1355 | 248 (18.3) | 86 | 3190 | 0 (0.0) | 5.11 |
| | | 3 | 1202 | 217 (18.1) | 94 | 3160 | 0 (0.0) | 3.78 |
| | F | 1 | 1375 | 368 (26.8) | 284 | 2870 | 118 (4.1) | 5.81 |
| | | 2 | 1466 | 320 (21.8) | 138 | 3570 | 114 (3.2) | 3.81 |
| | | 3 | 1414 | 331 (23.4) | 138 | 3490 | 103 (2.9) | 2.90 |
| Average | U | | 607 | 118 (20.6) | 39 | 1903 | 19 (1.2) | 2.37 |
| | F | | 876 | 215 (25.2) | 179 | 2180 | 102 (5.0) | 2.62 |

*U, unfertilized; F, fertilized.

Values in parenthesis are extractable P as a % of sediment total P and exchangeable ammonium as a % of sediment total N.

There was a strong relationship between the solids content of runoff and the sediment phosphorus concentration in the runoff. A similar relationship was observed between solids and the sediment nitrogen content of runoff. These findings suggest that the solids content of surface runoff provides a good indication of the relative amounts of sediment nitrogen and phosphorus present in runoff. It may be possible to obtain a semi-quantitative estimate of the sediment nitrogen and phosphorus content of runoff based upon solids content in a given watershed if most soils in the watershed are similar.

The solids content was also significantly correlated with the soluble organic phosphorus concentration, the soluble organic carbon content, and the exchangeable ammonium concentration in the sediment. Thus it appears that the solids content of surface runoff from these soils is a key factor in determining the concentrations of certain forms of nitrogen, phosphorus, and carbon in runoff. However, solids content may not always be related to sediment nitrogen and phosphorus content since soil type, slope of the soil, natural fertility and other soil associated factors can affect the composition of the sediments inducing variability. Therefore, the nitrogen and phosphorus concentration in sediment may change as related to the original soil because of selective enrichment by smaller size fractions, especially clay. When predictions of nutrient content of sediments is made these factors need to be considered.

Clay content of the runoff was related to solids, soluble organic phosphorus, sediment total phosphorus and organic carbon in the sediment. It appears that the clay fraction carried a large portion of these nutrients contained in the runoff. Clay particles especially the related amorphous material have a high affinity for phosphate ions and organic molecules.

A very high correlation coefficient ($r = 0.91$) was obtained for the relationship between the soluble inorganic phosphorus concentration in runoff and the equilibrium phosphorus concentration (EPC) of runoff sediment. It appears that the concentration of soluble inorganic phosphorus in runoff may be accurately estimated by determining the EPC of the sediment. It is interesting to note that the relationship between soluble inorganic phosphorus and sediment EPC was observed even when results from several soils were combined and when the solids content of runoff varied from 0.17 percent to 2.74 percent. These findings suggest that the relationship between the sediment EPC and the soluble inorganic phosphorus concentration in water is similar for different soil types.

The original soil EPC when compared to soluble inorganic phosphorus concentration of the runoff from unfertilized plots resulted in a correlation coefficient of 0.81 which indicates under certain conditions the original soil EPC may be useful in predicting the soluble inorganic phosphorus in runoff. The nature of the equilibrium between the soil and solution makes it possible for the soil to buffer solution phosphorus. Soil when associated with solutions of low phosphorus status may desorb phosphorus whereas under conditions of high concentrations of solution phosphorus the soil may sorb phosphorus. If the composition of the runoff is known, predictions can be made to assess the contribution of sediment phosphorus in runoff to the phosphorus status of lakes and streams.

Sediment phosphorus in runoff was related to the concentration of soluble phosphorus in runoff and to the concentration of soluble organic carbon and sediment organic carbon in runoff. As expected the concentration of extractable phosphorus in the sediment was directly related to the concentration of total phosphorus in the

## Table 7.18 Analysis of Soil Size Fractions

| Soil Type | Fraction | Percent of soil | Total N | Total P | Extractable P* | EPC+ |
|---|---|---|---|---|---|---|
| | | | μg/g | | | ng/ml |
| Haskins loam | whole soil | 100.0 | 1021 | 364 | 46 | |
| | sand | 43.0 | 166 | 168 | 29 | 5 |
| | silt | 44.5 | 710 | 240 | 36 | 3 |
| | clay | 12.4 | 4406 | 1135 | 155 | 28 |
| Morely clay loam | whole soil | 100.0 | 1240 | 366 | 12.4 | |
| | sand | 23.5 | 225 | 90 | 10.5 | 0 |
| | silt | 43.4 | 835 | 127 | 10.5 | 0 |
| | clay | 33.0 | 2165 | 739 | 16.1 | 0 |
| Hoytville silty clay | whole soil | 100.0 | 2969 | 1241 | 117 | |
| | sand | 14.2 | 424 | 704 | 49 | 0 |
| | silt | 42.1 | 1794 | 756 | 102 | 7 |
| | clay | 43.7 | 4466 | 1364 | 166 | 44 |
| Nappanee clay loam | whole soil | 100.0 | 1557 | 706 | 44 | |
| | sand | 28.9 | 182 | 399 | 21 | 1 |
| | silt | 41.6 | 972 | 335 | 34 | 2 |
| | clay | 29.5 | 3231 | 1109 | 75 | 9 |

*Bray P, (Jackson, 1970).

+EPC - equilibrium phosphorus concentration (Taylor and Kunishi, 1971).

sediment. The concentration of extractable phosphorus in sediment was also related to sediment EPC. This finding suggests that the EPC technique and the Bray P-1 extraction procedure measure a similar fraction of soil phosphorus which determines the concentration of orthophosphate in equilibrium solutions. It has been observed that EPC measures the buffering capacity of a soil for phosphate whereas Bray P-1 extraction measures the phosphate potential of the soil.

The soluble ammonium nitrogen concentration in runoff was related to the exchangeable ammonium nitrogen concentration in runoff and to the exchangeable ammonium nitrogen content of the sediment. This finding suggests that an equilibrium exists between the soluble ammonium in runoff and the exchangeable ammonium present on solids in runoff. Thus it may be possible to predict one of these forms of ammonium in runoff if the other form is known. Soluble organic nitrogen in runoff is related to the concentration of sediment nitrogen in runoff and to the concentration of exchangeable ammonium in the sediment. It appears likely that a given proportion of organic nitrogen in these soils is solubilized during runoff events and therefore soils containing high organic nitrogen contents have runoff higher in soluble organic nitrogen than soils containing low concentrations of organic matter.

The four soils used in the study were separated into their sand, silt, and clay fractions for chemical analysis. The fractionation procedure gave fractions which represented 94.3 percent of the weight of the original sample. A higher recovery could have been achieved if the large volumes of suspended clay could have been air-dried in a short period of time. The freezing process made recovery much faster since a major portion of the supernatant could be decanted.

The results of the chemical analysis of the soil constituents and the original soils are presented in table 7.18. The analyses of samples for total phosphorus, total nitrogen, and extractable phosphorus all indicate that the highest concentrations of nitrogen and phosphorus in soil are associated with the clay fraction.

Phosphorus adsorption on clays has been related to the presence of amorphous oxides and hydrous oxides of iron and aluminum. The presence of iron oxide and hydrous oxide coatings on clay mineral surfaces has been reported. Such coatings along with greater surface area may explain the fact that a large proportion of the total phosphorus in the soil is associated with the clay fractions. Since silt and clay are, in many cases, preferentially eroded, higher losses of sediment nitrogen and phosphorus would be expected than if the soil were eroded in mass. This observation has led to the use of enrichment ratios where the concentration of sand, silt, and clay in the particulate phase of surface runoff is compared to concentrations in the soil. Previous researchers have observed increases in clay content of eroded materials. For a soil containing 16 percent to 18 percent clay, clay percentage in the eroded material increased from 25 percent to 60 percent as runoff diminished from 2.7 inches to .01 inches (70 mm to 0.25 mm) of runoff per hour. Runoff from storms of lesser intensity may carry as much sediment phosphorus as intense storms due to greater enrichment during low runoff.

If selective erosion occurs, the potential for enriching water with nutrients is increased because the concentration of nutrients in the clay fraction is much higher than the whole soil. It is apparent that selective erosion occurred in these soils because the nitrogen and phosphorus concentration of the sediment from unfertilized plots are higher than those of the whole soil and in some cases higher than the concentration in the clay fraction of the soil. This finding suggests that the fine clay particles are being eroded preferentially and could be a potential source of nitrogen and phosphorus to the solution due to the higher nutrient concentration of the fine clay.

Phosphorus adsorption isotherms relations were determined for the three factions of each soil. The isotherms indicate clay has the greatest ability to buffer the soluble phosphorus concentration. The clays, when subjected to concentrations of soluble orthophosphate greater than the EPC, will sorb phosphorus from solution. Clay in stream and lake systems can serve as a phosphate sink during periods of high phosphorus concentration. Even though clay may hold the largest fraction of phosphorus in streams and lakes it also has the ability to maintain the concentration of phosphorus in solution at levels lower than in runoff which enters the water. The concentration maintained is most likely dependent upon the EPC of the eroded material and the EPC of the material present on the stream bank and lake bottoms.

## B. Conclusions

Fertilizers increase the soluble nitrate-nitrogen, ammonium nitrogen and orthophosphate-phosphorus content of runoff. These losses are small (none greater than

8.0 percent) as compared to the amount of fertilizer nutrient added to the soil. The soluble inorganic nitrogen and phosphorus in runoff are readily available for algal growth and therefore reduction of the concentration of nutrients in runoff is desirable.

Sediments contain the majority of nitrogen and phosphorus in runoff. Sediment nitrogen and phosphorus are not immediately available to aquatic plants but these forms may serve as potential nutrient sources. The greatest portion of nitrogen and phosphorus associated with sediment appears to be in the clay fraction. Soils susceptible to selective erosion may yield sediment which contain more nitrogen and phosphorus than the original soil since clay and silt percentages of sediment generally increase relative to the soil during erosion. The best approach for reducing nutrient loss from cropland appears to be erosion and runoff control.

Practices such as fertilizer incorporation are important as indicated by this study and previous investigations. Conservation tillage methods need to be evaluated with respect to control of erosion and runoff and suitability to present day farming practices.

The findings of this study allows one to draw certain implications about the composition of runoff from soils of the Upper Maumee River watershed. It appears that the solids and clay content of the runoff are the most important parameters in controlling the concentrations of several forms of nitrogen and phosphorus in runoff. The data suggests that control of soil erosion and proper incorporation of fertilizers (to prevent mass movement of fertilizer in runoff water) can greatly reduce the concentrations of nutrients in runoff from the soils studied.

The concentration of soluble inorganic phosphorus in runoff (possibly the most important single parameter in eutrophication) can be estimated by measurement of the EPC or the extractable phosphorus content of eroded material. The EPC value of unfertilized soil or soils in which phosphorus fertilizers have been incorporated can be used to estimate the soluble inorganic phosphorus concentration in runoff. These relationships should be very useful in development of models for prediction of nutrient loss in the Maumee River watershed.

The concentration of soluble ammonium in runoff can be estimated from the exchangeable ammonium content of the runoff sediment. It also appears likely that the exchangeable ammonium content of the soil is related to the soluble ammonium concentration in runoff. The concentration of nitrate in the runoff was not related to any runoff properties which were measured. This is to be expected in that nitrate is water soluble and is not associated with the solid phase of the soil. This finding suggests that development of a model for loss of nitrate in runoff water will be very difficult because nitrate losses are dependent upon a large number of hydrologic and soil factors.

## C. Laboratory Studies

Laboratory incubation experiments were conducted to evaluate the transformations of nitrogen and phosphorus in water systems. The treatments used in these experiments are summarized in table 7.19

### *1. Effect of Incubation Temperature*

The temperature zone subject to temperature variations throughout the year and

### Table 7.19 Treatments used in Simulated Aquatic System Study

| Treatment | Amendment* | Temperature | Aeration** status | Pretreatment |
|---|---|---|---|---|
| | | °C | | |
| 1 | None | 5 | static | None |
| 2 | None | 13 | static | None |
| 3 | None | 23 | static | None |
| 4 | None | 33 | static | None |
| 5 | None | 23 | anaerobic (shake) | None |
| 6 | None | 23 | aerobic (shake) | None |
| 7 | None | 23 | static | None |
| 8 | 34 µg P + 1500 µg N | 23 | static | Sol. Replacement |
| 9 | 84 µg P + 6000 µg N | 23 | static | None |
| 10 | $CaCO_3$ | 23 | static | None |

* None, 5 ml of deionized added to water sample; $CaCO_3$, 5 ml of deionized water + 2 gm of $CaCO_3$; 34 µg P + 1500 µg P, 5 ml of deionized water containing 34 µg of P as $KH_2PO_4$ and 1500 µg N as $NH_4NO_3$; 84 µg P + 6000 µg N, 5 ml of deionized water containing 84 µg P as $KH_2PO_4$ and 6000 µg N as $NH_4NO_3$.

** Static, samples incubated in polythylene bottles covered with polyethylene film; anaerobic, samples incubated in stoppered glass bottles after purging with helium; aerobic, samples subjected to shaking while incubated in polyethylene bottles covered with polyethylene film.

Solution replacement, liquid phase of runoff removed by centrifugation and decanted and 150 ml of deionized water added.

thus the temperature regime in surface waters will vary diurnally and seasonally. The effects of incubation temperature on the soluble phosphorus and inorganic nitrogen composition of creek water are given in table 7.20. The concentration of soluble inorganic phosphorus increased significantly with time at all incubation temperatures; however, the increases were greater at higher temperatures. The increase in inorganic phosphorus was approximately one-third greater for samples incubated at 33°C as compared to those incubated at 5°C. The soluble organic phosphorus concentration in samples decreased with time, but the rate of decrease was slower at the lowest incubation temperature. The concentration of total soluble phosphorus generally increased with time of incubation. This finding suggests that the increase in soluble inorganic phosphorus in samples is not entirely the result of mineralization of soluble organic phosphorus, but may in part result from desorption of inorganic phosphorus from the sediment or mineralization of organic phosphorus in the sediment. During the 12 weeks of incubation 1.8, 2.1, 3.75, and 8.25 g of phosphorus per sample were released from the sediment to the solution phase of samples incubated at 5, 15, 23, and 33°C, respectively.

In all samples except those incubated at 33°C, the ammonium-nitrogen content increased during the first week, probably as a result of mineralization of organic nitrogen. Nitrification was rapid in samples incubated at all temperatures as evi-

## Table 7.20 Effect of Incubation Temperature on the Concentration of Soluble N and P in a Simulated Aquatic System

| Treatment | Incubation time (weeks) | Concentration of soluble | | | | Change in Concentration during incubation | |
|---|---|---|---|---|---|---|---|
| | | Inorg-P | Org. P | $NH_4^+$-N | $NO_3^-$-N | Sol-P | Sol. inorg-N |
| | | mg/1 | | | | mg/1 | |
| 5°C | 0 | .189 | .104 | 0.54 | 2.88 | - | - |
| | 1 | .161 | .132 | 0.97 | 2.92 | .000 | .47 |
| | 3 | .182 | .123 | 1.20 | 3.19 | .012 | .97 |
| | 6 | .280 | .093 | 0.76 | 3.86 | .080 | 1.20 |
| | 12 | .286 | .019 | 0.10 | 4.57 | .012 | 1.25 |
| 13°C | 0 | .189 | .104 | 0.54 | 2.88 | - | - |
| | 1 | .210 | .076 | 1.16 | 2.92 | -.007 | .66 |
| | 3 | .261 | .017 | 0.24 | 4.28 | -.015 | 1.10 |
| | 6 | .288 | .043 | 0.10 | 4.59 | .038 | 1.27 |
| | 12 | .295 | .012 | 0.07 | 4.84 | .014 | 1.49 |
| 23°C | 0 | .189 | .104 | .054 | 2.88 | - | - |
| | 1 | .220 | .090 | 1.15 | 2.97 | .017 | 0.70 |
| | 3 | .258 | .024 | 0.21 | 4.36 | -.003 | 1.15 |
| | 6 | .309 | .018 | 0.22 | 4.84 | .034 | 1.64 |
| | 12 | .314 | .004 | 0.10 | 4.77 | .025 | 1.45 |
| 33°C | 0 | .189 | .104 | 0.54 | 2.88 | - | - |
| | 1 | .279 | .080 | 0.19 | 3.82 | -.066 | 0.59 |
| | 3 | .280 | .018 | 0.16 | 4.10 | .005 | 0.84 |
| | 6 | .315 | .024 | 0.22 | 4.93 | .046 | 1.73 |
| | 12 | .340 | .008 | 0.07 | 4.89 | .055 | 1.54 |

denced by the increase in nitrate content with time. The nitrate concentration in incubated samples increased steadily with time and reached approximately the same level in all treatments after 12 weeks of incubation. After 12 weeks of incubation 188, 224, 218, 231$\mu g$ of nitrogen per sample were released from the sediment to the solution phase in samples incubated at 5, 13, 23, and 33°C, respectively. The increase in soluble inorganic nitrogen is likely the result of mineralization of organic nitrogen present in the sediment phase of creek water.

As stated previously, temperature has a definite effect on the rate with which insoluble nutrients become available and on the amount of nutrients that are converted to water soluble forms. The increasing amounts of nitrogen and phospherous converted to water soluble forms were directly proportional to the incubation temperature. This is a significant finding since aquatic plants exhibit accelerated growth rates during periods of elevated water temperature, provided the temperature is within the optimum range for growth. If water temperatures increase in a lake or pond in which algal growth may be a problem, the data obtained from incubation experiments indicate that increased amounts of nitrogen and phosphorus will become available to aquatic plants. In lakes where the temperature does not exceed 5°C, the nutrient status would be much lower and thus, reduce the potential for the growth of aquatic plants.

## 2. *Effect of Aeration Status and Shaking*

Sediments are subjected to various levels of aeration during transportation and deposition in natural waters. Aeration is known to have a great effect upon the soluble nitrogen and phosphorus in water-sediment systems. It is essential to determine the role of sediments in supplying soluble nutrients in natural water systems.

The effects of aeration status and shaking on the soluble nitrogen and phosphorus components of creek water incubated for 12 weeks is given in table 7.21. It was anticipated that shaking would increase the degree of aeration in samples; however, there was little difference in dissolved oxygen content of static or shaken samples. The dissolved oxygen measurements taken after incubation of helium purged samples show that anaerobic conditions were not maintained throughout the incubation period; however, the dissolved oxygen content was much lower than in those samples which were not helium purged. The soluble inorganic phosphorus concentration increased with time in aerobic samples; however, in helium purged samples the soluble inorganic phosphorus increased for the first three weeks and then decreased during the last nine weeks of incubation. The levels of soluble inorganic phosphorus were significantly higher in aerobic samples which were shaken as compared to those which were static. The soluble organic phosphorus content of all samples tended to decrease with time; however, the rate of decrease of soluble organic phosphorus content during the last 11 weeks of incubation was greatest in samples which were shaken. The total soluble phosphorus content of all samples tended to reach a peak value after one week of incubation and then remain relatively constant or decline with time thereafter. In aerobic samples, the decline in total soluble phosphorus content resulted from more rapid decreases in soluble organic phosphorus then increases in soluble inorganic phosphorus, whereas in helium purged samples soluble organic phosphorus rapidly decreased and soluble

Table 7.21 The Effect of Aeration Status and Shaking on the Concentration of Soluble N and P in a Simulated Aquatic System

| Treatment | Incubation time (weeks) | Dissolved $O_2$ content | Concentration of soluble |  |  |  | Change in Concentration during incubation |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | Inorg P | Org. P | $NH_4^+$-N | $NO_3^-$-N | Sol-P | Sol inorg-P |
|  |  | ← |  | mg/1 |  |  |  | mg/1 → |
| Aerobic static | 0 | - | 0.189 | 0.104 | 0.54 | 2.88 | - | - |
|  | 1 | 8.60 | 0.220 | 0.090 | 1.15 | 2.97 | 0.017 | 0.70 |
|  | 3 | 8.85 | 0.258 | 0.024 | 0.21 | 4.36 | 0.003 | 1.15 |
|  | 6 | 9.40 | 0.309 | 0.018 | 0.22 | 4.84 | 0.034 | 1.64 |
|  | 12 | 9.55 | 0.314 | 0.004 | 0.10 | 4.77 | 0.025 | 1.45 |
| aerobic shake | 0 | - | 0.189 | 0.104 | 0.54 | 2.88 | - | - |
|  | 1 | 8.70 | 0.275 | 0.110 | 0.07 | 4.12 | 0.092 | 0.77 |
|  | 3 | 8.75 | 0.342 | 0.000 | 0.19 | 4.79 | 0.049 | 1.56 |
|  | 6 | - | - | - | - | - | - | - |
|  | 12 | 9.30 | 0.361 | 0.000 | 0.34 | 5.28 | 0.068 | 2.20 |
| Helium purged shake | 0 | - | 0.189 | 0.104 | 0.54 | 2.88 | - | - |
|  | 1 | 2.30 | 0.228 | 0.103 | 0.70 | 3.49 | 0.038 | 0.77 |
|  | 3 | 2.00 | 0.300 | 0.000 | 0.09 | 4.62 | 0.007 | 1.29 |
|  | 6 | 2.60 | 0.247 | 0.000 | 0.15 | 4.76 | 0.046 | 1.49 |
|  | 12 | 0.50 | 0.236 | 0.000 | 0.17 | 4.91 | 0.057 | 1.66 |

**Table 7.22 The Effect of Calcium Carbonate Amendment on the Level of Soluble N and P in a Simulated Aquatic System**

| Treatment | Incubation time (weeks) | Concentration of soluble | | | | Change in concentration during incubation | |
|---|---|---|---|---|---|---|---|
| | | Inorg-P | Org. P | $NH_4^+$-N | $NO_3^-$-N | Sol-P | Sol inorg-N |
| mg/1 | | | | | | | |
| None | 0 | 0.189 | 0.104 | 0.54 | 2.88 | - | - |
| | 1 | 0.220 | 0.090 | 1.15 | 2.97 | 0.017 | 0.69 |
| | 3 | 0.258 | 0.024 | 0.21 | 4.36 | 0.003 | 1.14 |
| | 6 | 0.309 | 0.018 | 0.21 | 4.84 | 0.034 | 1.63 |
| | 12 | 0.314 | 0.004 | 0.10 | 4.77 | 0.025 | 1.44 |
| $CaCO_3$* | 0 | 0.185 | 0.117 | 0.57 | 2.97 | - | - |
| | 1 | 0.203 | 0.050 | 0.89 | 3.11 | 0.049 | 0.46 |
| | 3 | 0.260 | 0.013 | 0.14 | 4.81 | 0.029 | 1.41 |
| | 6 | 0.270 | 0.015 | 0.29 | 4.64 | 0.017 | 1.39 |
| | 12 | 0.289 | 0.000 | 0.36 | 5.20 | 0.013 | 2.02 |

* 2 grams of $CACO_3$ added per sample.

inorganic phosphorus increased for three weeks and then decreased giving a net decrease in total soluble phosphorus. During 12 weeks of incubation 3.75μg and 10.2 of phosphorus were released to the solution phase from sediment in aerobic samples which were static and shaken, respectively. In helium purged samples 8.55μg phosphorus per sample was removed from the solution phase during 12 weeks of incubation.

The ammonium content of aerobic static samples and helium purged samples increased during the first week of incubation and then decreased to a low level during the next two weeks and then remained low during the remainder of the incubation period. The ammonium concentration in aerobic shaken samples decreased during the first week of incubation and then slowly increased during the remaining 11 weeks. The nitrate content of all samples increased rapidly during the initial one to three weeks of incubation and then increased slowly during the remainder of the incubation period. The finding that nitrification was occurring in helium purged samples is good evidence that the samples were not anaerobic and that nitrification is not limited by relatively low dissolved oxygen contents in the water. The soluble inorganic nitrogen content of samples tended to increase with time throughout the incubation. During 12 weeks of incubation 218, 330, and 249μg of inorganic phosphorus per sample were released from sediment to the solution phase in aerobic static, aerobic shaken, and helium-purged shaken samples, respectively. This finding suggests that shaking may increase the mineralization of organic nitrogen and that a reduction of dissolved oxygen in water may decrease the mineralization of organic nitrogen.

### 3. *Effect of Calcium Carbonate Addition*

Sediments may contain various concentrations of calcium carbonate and it has been reported that calcium carbonate has the ability to sorb phosphate. However, it has been found that the phosphorus sorption capacity of lake sediments tended to be inversely related to calcium carbonate content. Since eroded soil materials may contain significant amounts of calcium carbonate, it is desirable to study the effects of calcium carbonate on solubility in sediment-water systems.

The effects of adding calcium carbonate on the soluble nutrient levels in creek water samples incubated for 12 weeks is given in table 7.22. The finding that addition of large amounts of calcium carbonate did not significantly decrease the initial levels of soluble inorganic phosphorus or soluble organic phosphorus in water samples suggests that calcium carbonate does not sorb soluble phosphorus in samples of Black Creek water. The levels of soluble inorganic phosphorus increased with time in both calcium carbonate amended and unamended samples. The soluble organic phosphorus concentration decreased with time in both amended and unamended samples, but the rate of decrease was more rapid in calcium carbonate amended samples. The total soluble phosphorus content of calcium carbonate amended samples decreased during the first week of incubation and then increased slowly during the remainder of the incubation period. The total soluble phosphorus content of unamended samples increased for the first week of incubation, decreased during the next two weeks, and then increased to a near constant level for the remainder of the incubation period. During the 12 week incubation period, 3.75μg of phosphorus per sample were released to the solution phase of unamended samples, whereas in calcium carbonate unamended samples, 1.95μg of phosphorus were removed from solution. The effect of calcium carbonate on the total soluble phosphorus content of water samples was likely due to decreased desorption of inorganic phosphorus from sediment or to decreased mineralization of organic phosphorus in sediment in association with increased sorption of soluble organic phosphorus by the sediment.

The soluble ammonium content of calcium carbonate amended samples increased during the first week of incubation and then declined to a low level for the remainder of the incubation period. The nitrate concentration increased with time in both calcium carbonate amended and unamended samples. There was little effect of calcium carbonate addition on the apparent nitrification rate in samples. The total soluble inorganic nitrogen content of unamended and calcium carbonate samples increased at about the same rate during the first six weeks of incubation. However after twelve weeks of incubation 216μg nitrogen per sample had been released to the solution in unamended samples whereas 303μg nitrogen were released in calcium carbonate may promote long term mineralization of sediment organic nitrogen.

Table 7.23 gives data on the effects of the initial inorganic phosphorus concentration on the level of soluble phosphorus in creek water subjected to laboratory incubation. Replacement of the liquid phase of the creek water samples with distilled water markedly lowered the initial soluble inorganic phosphorus content and increased the soluble organic phosphorus content of the samples relative to the untreated samples. Addition of inorganic phosphorus (34 or 84μg per sample) markedly increased the soluble inorganic phosphorus content of water samples (91 percent and 63 percent of the added inorganic phosphorus remained in solution at the low and high addition rates, respectively). Addition of 34μg of inorganic phosphorus per sample decreased the level of soluble organic phosphorus, whereas addition of 84μg phosphorus per sample increased the soluble organic phosphorus concentration. The soluble inorganic phosphorus content of samples whose liquid phase was replaced by water increased with time up to three weeks of incubation and then remained relatively constant for the remainder of the incubation period. The soluble inorganic phosphorus content of samples amended with inorganic phosphorus tended to remain relatively constant with time during incubation. The soluble organic phosphorus content of most samples decreased rapidly during the first three weeks of incubation and then decreased slowly thereafter. In samples amended with 34μg of inorganic phosphorus the soluble organic phosphorus content increased rapidly during the first week of incubation and then decreased rapidly thereafter. The total soluble phosphorus content of samples whose liquid phase was replaced by distilled water decreased throughout the period of incubation. The total soluble phosphorus content of samples amended with 34μg of inorganic phosphorus remained relatively constant throughout the incubation period, however, in samples amended with 84μg of inorganic phosphorus the total soluble phosphorus content decreased markedly for the first three weeks and then remained constant. The fact that the soluble organic phosphorus content of amended samples was decreasing faster than the soluble inorganic content was increasing suggests that at least a portion of the decrease in organic phosphorus from solution is the result of sorption of organic phosphorus compounds by sediments. During 12 weeks of incubation, the amount of phosphorus lost from solution (sorbed by sediments or immobilized in microbial cells) was 11.4, 2.25, and 22.95µg of phosphorus per sample for samples with liquid phase replacement, amendment with 34 µg of phosphorus, and amendment with 84µg of phosphorus, respectively.

The effects of the initial levels of soluble inorganic nitrogen on the concentrations of ammonium and nitrate in creek water samples incubated for 12 weeks is given in table 7.24. Replacement of the liquid phase of samples with distilled water markedly reduced the initial concentrations of ammonium and nitrate in incubated samples. Addition of ammonium nitrate (1500 or 6000µg nitrogen per sample) increased the initial concentration of both forms of inorganic nitrogen in solution although from 12 to 24 percent of the added ammonium was apparently removed from solution by cation exchange reactions with sediment. The ammonium concentration in samples having their liquid phase replaced with distilled water remained low throughout 12 weeks of incubation. The ammonium concentration in samples treated with ammonium nitrate remained constant for one week and then decreased to very low values during the next two weeks of incubation. The nitrate

## Table 7.23 The Effect of Inorganic P Addition on the Level of Soluble Phosphorus in a Simulated Aquatic System

| Treatment | Incubation time (weeks) | Concentration of soluble | | Change in concentration of total soluble P during incubation |
|---|---|---|---|---|
| | | Inorg. P | Org. P | |
| | | mg/1 | | |
| Deionized $H_2O$* | 0 | 0.052 | 0.181 | - |
| | 1 | 0.125 | 0.083 | -.026 |
| | 3 | 0.179 | 0.009 | -.059 |
| | 6 | 0.171 | 0.005 | -.057 |
| | 12 | 0.157 | 0.000 | -.076 |
| None | 0 | 0.189 | 0.104 | - |
| | 1 | 0.220 | 0.090 | .017 |
| | 3 | 0.258 | 0.024 | -.013 |
| | 6 | 0.309 | 0.018 | .035 |
| | 12 | 0.314 | 0.004 | .025 |
| 34 µgP added | 0 | 0.396 | 0.055 | - |
| | 1 | 0.404 | 0.040 | -.050 |
| | 3 | 0.412 | 0.025 | -.013 |
| | 6 | 0.401 | 0.008 | -.041 |
| | 12 | 0.433 | 0.002 | -.015 |
| 84 µgP added | 0 | 0.545 | 0.159 | - |
| | 1 | 0.466 | 0.174 | -.064 |
| | 3 | 0.513 | 0.029 | -.162 |
| | 6 | 0.551 | 0.014 | -.139 |
| | 12 | 0.544 | 0.007 | -.153 |

*Entire liquid phase of sample replaced with deionized water.

†The above is not an amount but a concentration.

## Table 7.24 The Effect of Ammonium Nitrate Addition on the Concentration of Soluble N in a Simulated Aquatic System

| Treatment | Incubation time (weeks) | Concentration of soluble $NH_4^+$-N | Concentration of soluble $NO_3^-$-N | Change in concentration of soluble inorganic N during incubation |
|---|---|---|---|---|
| | | mg/l | | |
| Deionized $H_2O$* | 0 | 0.26 | 0.28 | - |
| | 1 | 0.21 | 0.11 | -0.21 |
| | 3 | 0.14 | 0.80 | 0.40 |
| | 6 | 0.20 | 0.93 | 0.58 |
| | 12 | 0.17 | 0.80 | 0.44 |
| None | 0 | 0.54 | 2.88 | - |
| | 1 | 1.15 | 2.97 | 0.72 |
| | 3 | 0.21 | 4.36 | 1.17 |
| | 6 | 0.22 | 4.84 | 1.66 |
| | 12 | 0.10 | 4.77 | 1.64 |
| 1500 μgN added | 0 | 4.36 | 7.14 | - |
| | 1 | 4.34 | 7.88 | 0.71 |
| | 3 | 0.19 | 13.33 | 2.00 |
| | 6 | 0.22 | 13.34 | 2.05 |
| | 12 | 0.32 | 13.22 | 2.03 |
| 6000 μgN added | 0 | 18.12 | 21.64 | - |
| | 1 | 18.92 | 22.89 | 2.14 |
| | 3 | 0.22 | 43.06 | 3.60 |
| | 6 | 0.24 | 43.20 | 3.86 |
| | 12 | 0.22 | 42.95 | 3.50 |

*Entire liquid phase of sample replaced with deionized water.

content of samples having their liquid phase replaced with distilled water tended to increase slowly during the incubation period. The nitrate content of samples amended with ammonium nitrate increased slowing during the first week of incubation, then increased rapidly during the next two weeks, and then remained relatively constant throughout the remainder of the incubation period.

The total soluble nitrogen content of samples whose liquid phase was replaced with distilled water tended to increase slightly as a result of incubation indicating that mineralization was slow in that system. The total soluble nitrogen content of samples amended with ammonium nitrate increased significantly during the first three weeks of incubation and then remained relatively constant for the remainder of the 12 week period. The net amounts of inorganic nitrogen formed during 12 weeks of incubation were 66, 246, 305, 525μg per sample for samples with liquid phase replacement, no treatment, addition of 1500μg nitrogen, and addition of 6000 μg nitrogen, respectively. The finding that less nitrogen is mineralized in samples with liquid phase replacement as compared to untreated samples suggests that a portion of the nitrogen mineralized is soluble organic nitrogen lost when the liquid phase was removed. The finding that more nitrogen is mineralized in samples treated with ammonium nitrate than in untreated samples suggests that a "priming effect" of inorganic nitrogen on mineralization may be significant in aquatic systems.

From the data collected during the incubation of the stream samples under the various environmental conditions, it can be concluded that there are both long-term and short-term transformations occurring which influence the amounts and forms of nitrogen and phosphorus found in the solution phase.

Short-term transformations appear to be sorption or desorption of both organic and inorganic phosphorus and possibly the release of sorbed phosphorus from soil minerals and dissolution of phosphorus occluded in iron and aluminum. The short-term transformations influencing the nitrogen and organic phosphorus contents of water are much more dependent upon the factors affecting microbial growth since transformations are largely carried out by microorganisms. Microbiological transformations may occur in very short periods of time if conditions are favorable for organisms or long periods when conditions are unfavorable. The short-term processes involving inorganic phosphorus transformations are more physiochemical in nature and therefore not so dependent on environmental factors.

The long-term processes involved in nitrogen and phosphorus transformations in water systems are likely to be the mineralization of organic nitrogen and phosphorus components in solution and in the sediment. Based on data obtained in this study, mineralization processes appear to be major long-term process leading to higher soluble nitrogen and phosphorus concentrations in incubated samples.

The soluble inorganic phosphorus concentration in most samples increased slowly with time during the incubation period. It appears this increase in soluble inorganic phosphorus was due mainly to the mineralization of soluble and sediment organic phosphorus. During the mineralization process the sorption-desorption process controls the equilibrium obtained between the sediment and solution.

In aquatic systems amended with calcium carbonate the concentration of total soluble phosphorus remained relatively constant indicating that calcium carbonate may decrease mineralization of sediment organic phosphorus. Increased content of dissolved oxygen and shaking of samples increased the concentration of soluble inorganic phosphorus and decreased the concentration of organic phosphorus. The overall effect was an increase in total soluble phosphorus during the incubation.

Addition of inorganic phosphorus to samples released organic phosphorus into solution most likely by replacement of organic phosphorus compounds sorbed on soil colloid surfaces by added inorganic phosphorus. The total soluble phosphorus content of samples treated with inorganic phosphorus decreased during the 12-week period indicating that soluble organic phosphorus was sorbed by the sediments. The samples in which the solution was replaced by deionized water were unable to attain the original concentration of inorganic phosphorus by desorption processes and part of the soluble organic phosphorus present in the liquid phase was sorbed by the sediment.

A 33°C incubation temperature increased the rate of mineralization of phosphorus and increased the final total soluble phosphorus concentration by a significant amount. A 5°C incubation temperature decreased the rate of mineralization of organic phosphorus.

The treatments applied which would increase microbial growth also enhanced the mineralization of nitrogen and as a final result the concentration of nitrate-nitrogen in solution increased. Aeration, calcium carbonate amendment, increased temperature and the addition of ammonium nitrate all had positive effects on the mineralization of nitrogen and the final total soluble inorganic nitrogen concentration. Low temperature seemed to have the greatest negative effect on the concentration of soluble inorganic nitrogen, but there were still increases in the solution concentration over the 12 week incubation period.

## 6. Sediment Delivery Analysis on the Maumee River

The various dynamic responses of the Maumee River and its many tributaries to rainfall, temperature changes, seasonal changes, etc. are of great importance in trying to understand the process of sediment production and delivery in the Maumee River basin. These relationships are basic to the modeling problem.

The data analyzed in this report were collected by the United States Geological Survey at its gaging station at Waterville, Ohio and by the United States Environmental Data Service at its stations in Fort Wayne, Indiana (Baer Field); Defiance, Ohio; and Toledo, Ohio (Blade station). The period of time covered in this initial study was from October, 1961, to October, 1971 (ten complete water years).

The USGS data used were daily average values for flow, sediment concentration, and sediment load. This data was then converted into plotable files with October 1 of each year as day 1 of that water year.

The USEDS data were compiled on a daily basis and weighted to give a daily, basin-wide average value. The weighting factors were based on the percentage of basin area represented by each station. Hence, Fort Wayne's factor was 0.30, Defiance's factor was 0.45, and Toledo's factor was 0.25. Soil temperature data were compiled from USEDS data for Lafayette, Indiana (4 inches deep-under grass), since Lafayette was nearly at the same latitude.

The data were plotted in order to observe the times-of-peak and other occurrences and to see how the parameters of rainfall, soil temperature, and flow magnitude affect the sediment carrying characteristics of the river. The plots were broken into four-month periods for ease in interpretation.

A qualitative and quantitative analysis was made on the ten years of data on the relationships between the various parameters. It was immediately evident that the months of December through May were responsible for practically all of the sediment delivered. Thus, the analyses were pointed toward this time period.

From historical data, the annual long term sediment yield from the Maumee River into Lake Erie is approximately 2,000,000 tons (1,800,000 metric tons) or, in terms of the basin area, about 936 lbs/ac (105 kg/ha. The annual long term precipitation over the Maumee River Basin is around 33 inches (840 mm). Of that amount, less than one-third or around 9.4 inches (240 mm) is runoff into Lake Erie.

The annual precipitation for the Maumee River Basin and the annual sediment yield and discharge from the Maumee River into Lake Erie for a ten-year period, October, 1961, to October, 1971, are presented in table 7.25. According to table 7.25, the average annual values for precipitation and discharge for the ten-year period were 32 inches and 9 inches (808 mm and 230 mm), respectively, which were a little below the long term values. The average annual sediment yield in terms of the basin area, however, was only 441 lbs/ac (495 kg/ha) which was about one-half the normally accepted value of 937 lbs/ac (1050 kg/ha). Since the accepted value was even exceeded in any of the ten years and really only approached once with a value of 882 lbs/ac (989 kg/ha) in 1967-68, the normally accepted value of 937 lbs/ac (1050 kg/ha) is probably high. While the average annual sediment yield was based only on measurements of the suspended sediment load, it is highly improbable that bed load could account for differences of this magnitude.

The annual precipitation for the 10-year period seems to be part of some cyclical pattern. Less than normal precipitation occurred from 1961 to 1966 and above normal precipitation from 1967 to 1971. The years with the highest precipitation had the highest runoff and also the highest percentage of precipitation occurring as runoff. As a consequence, the average annual sediment yield for the last five years was 593 lbs/ac (665 kg/ha), more than twice the 289 lbs/ac (324 kg/ha) yield for the first five years.

The plots of flow, sediment concentration, sediment load, soil temperature, and precipitation versus time are presented in figures 7.22 to 7.51. A quantitative analysis of the average monthly values of discharge and sediment yield was conducted to ascertain the peak values and months of greatest activity. The results are shown in figure 7.52. Figure 7.52 (a) shows the numerical values of the average monthly discharges and sediment yields. Figure 7.52 (b) indicates the percentage, by month, of the average yearly flow and sediment yield for each of the ten water years.

Winter-type precipitation events, being frontal in nature, are much more widespread in coverage than the normal convective summer-type storms. This coupled with the fact of freeze-thaw and snow melt during precipitation events leads one to the conclusion that the late winter and early spring storms have a greater capability for production and transport of sediment. As can be seen in figure 7.52, the six-month period, June through November, only had 16 percent of the total flow and 8 percent of the sediment yield for the ten-year period. On the other hand, the six-month period, December through May, had 84 percent and 92 percent of the total flow and sediment yield, respectively.

**Table 7.25 Average Annual Precipitation for the Maumee River Basin and Annual Sediment Yield and Discharge from the Maumee River for a 10-year Period, October, 1961, to October, 1972**

| Water Year | Precipitation[a] (mm) | Discharge (mm over basin) | Ratio of discharge & precipiation (%) | Sediment Yield (kg/ha) |
|---|---|---|---|---|
| 1970-71 | 739 | 198 | 27 | 304 |
| 1969-70 | 898 | 267 | 30 | 609 |
| 1968-69 | 938 | 320 | 34 | 662 |
| 1967-68 | 980 | 345 | 35 | 989 |
| 1966-67 | 835 | 348 | 42 | 763 |
| 1965-66 | 807 | 181 | 22 | 202 |
| 1964-65 | 826 | 196 | 24 | 516 |
| 1963-64 | 716 | 150 | 21 | 427 |
| 1962-63 | 656 | 109 | 17 | 159 |
| 1961-62 | 683 | 186 | 27 | 323 |
| Average | 808 | 230 | 28 | 495 |

[a] Average of three locations: Fort Wayne, Defiance and Toledo.

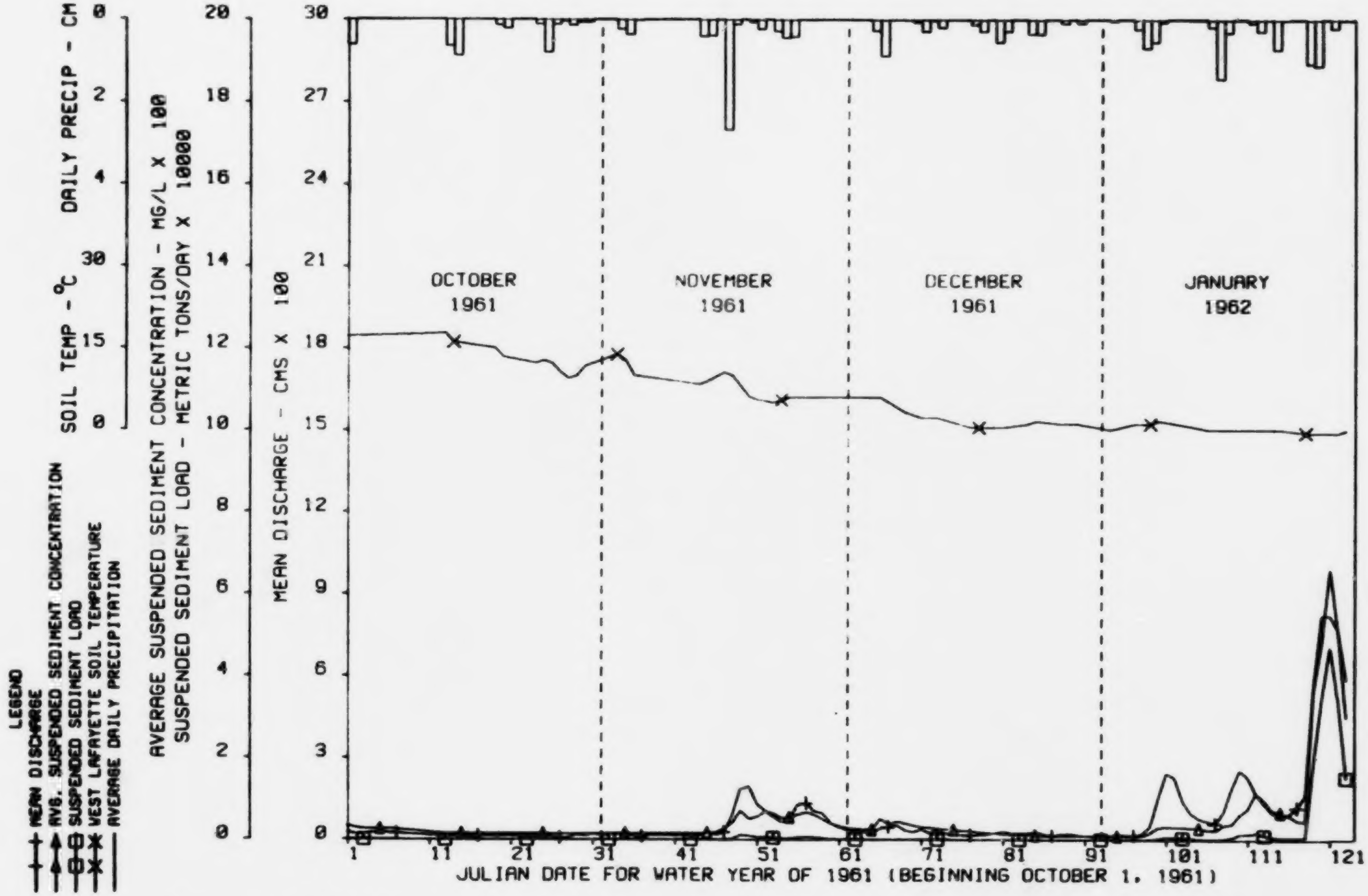


Figure 7.22 Sediment Load and Related Parameters for the Maumee River from October, 1961, to January, 1962

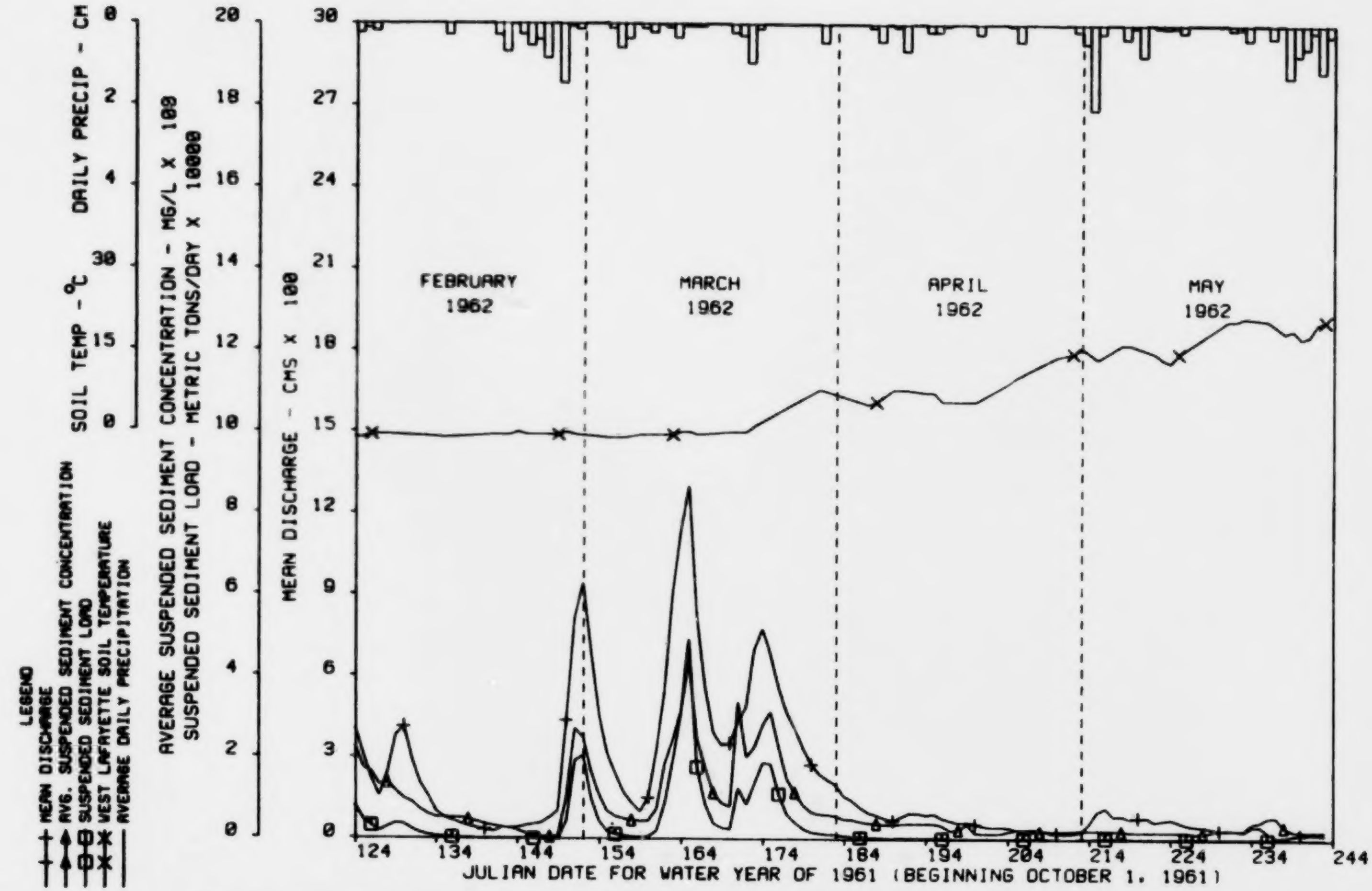


Figure 7.23 Sediment Load and Related Parameters for the Maumee River from February, 1962, to May, 1962

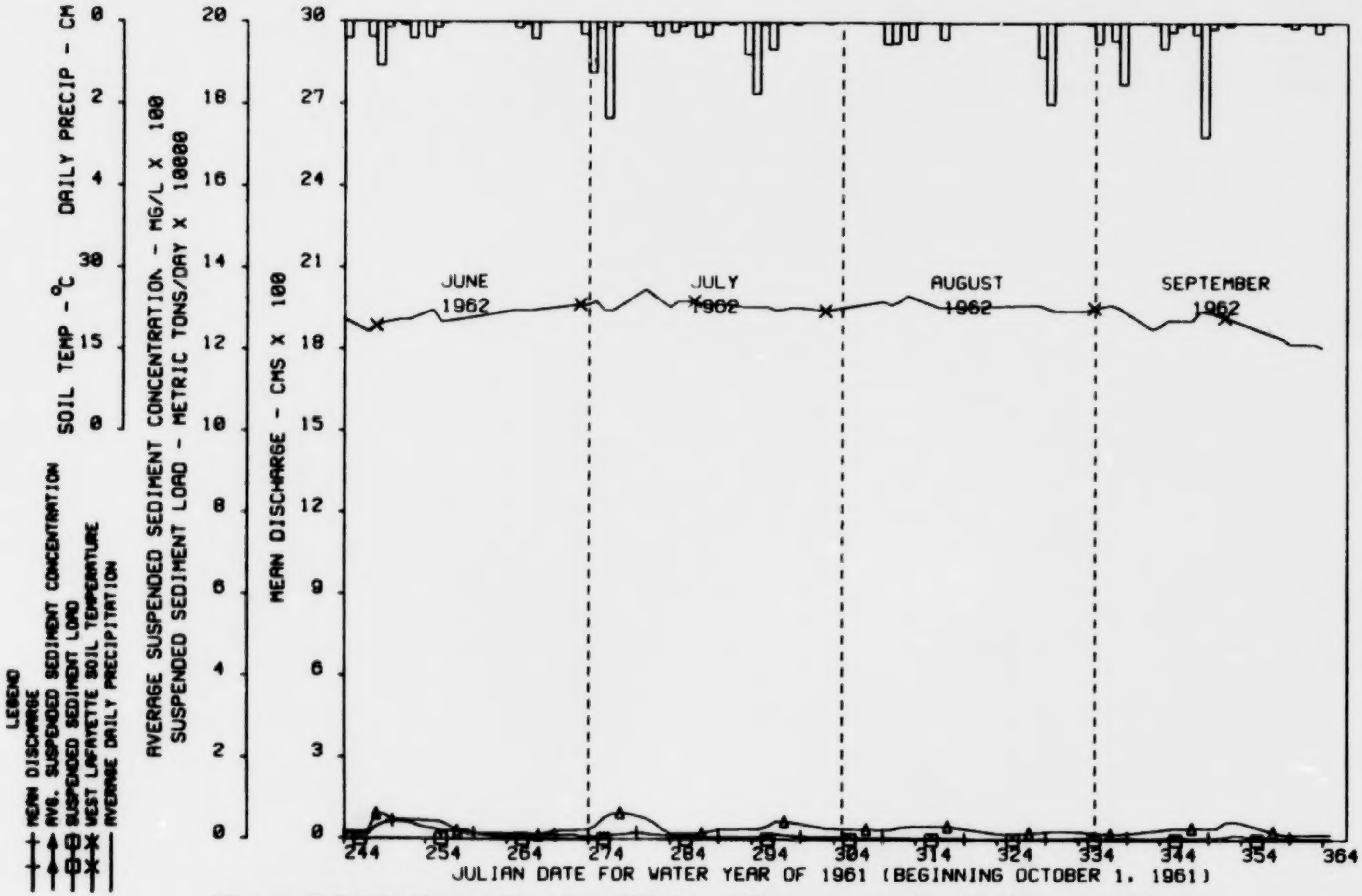


**Figure 7.24 Sediment Load and Related Parameters for the Maumee River from June, 1962, to September, 1962**

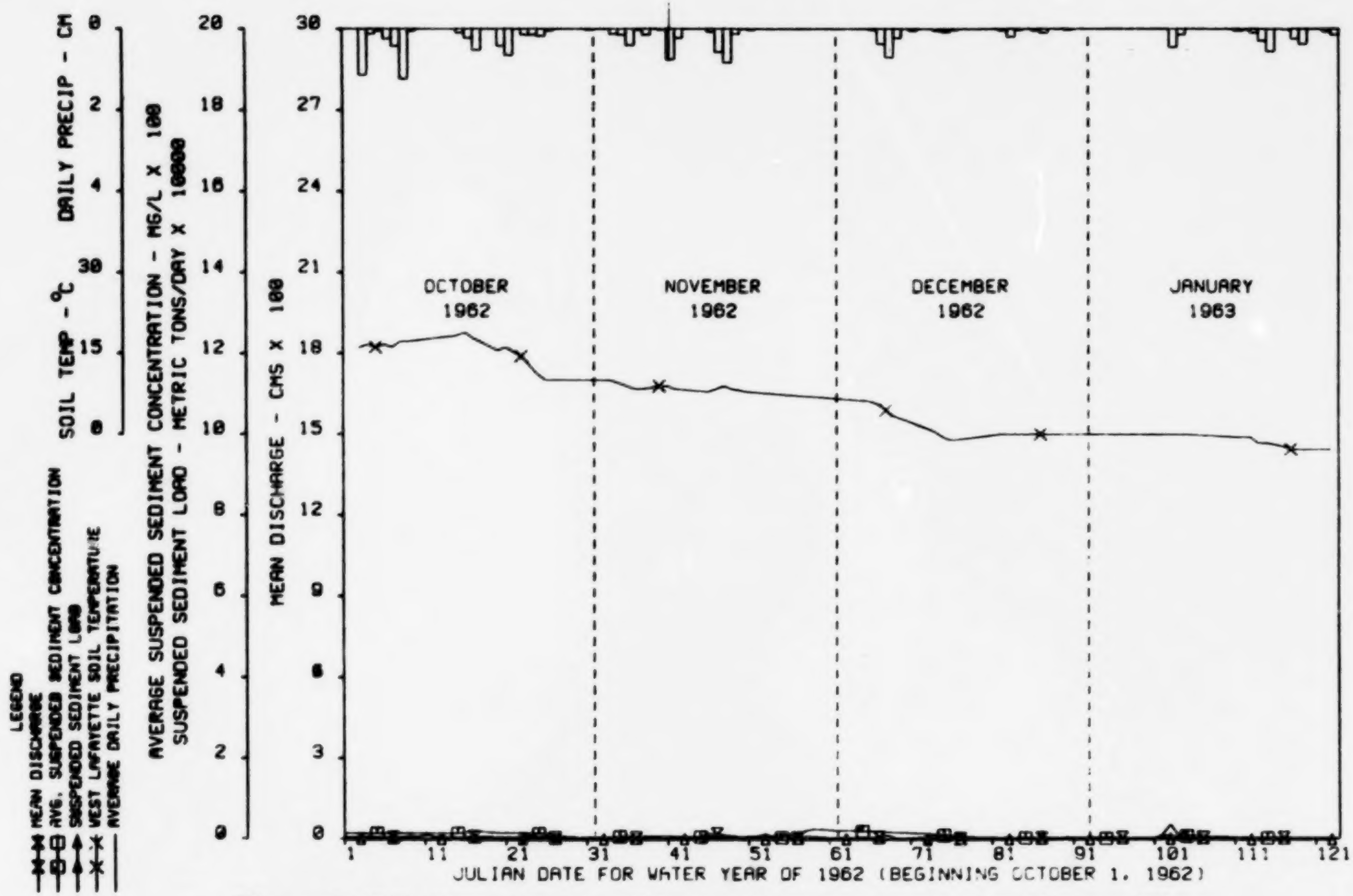


**Figure 7.25 Sediment Load and Related Parameters for the Maumee River from October, 1962, to January, 1963**

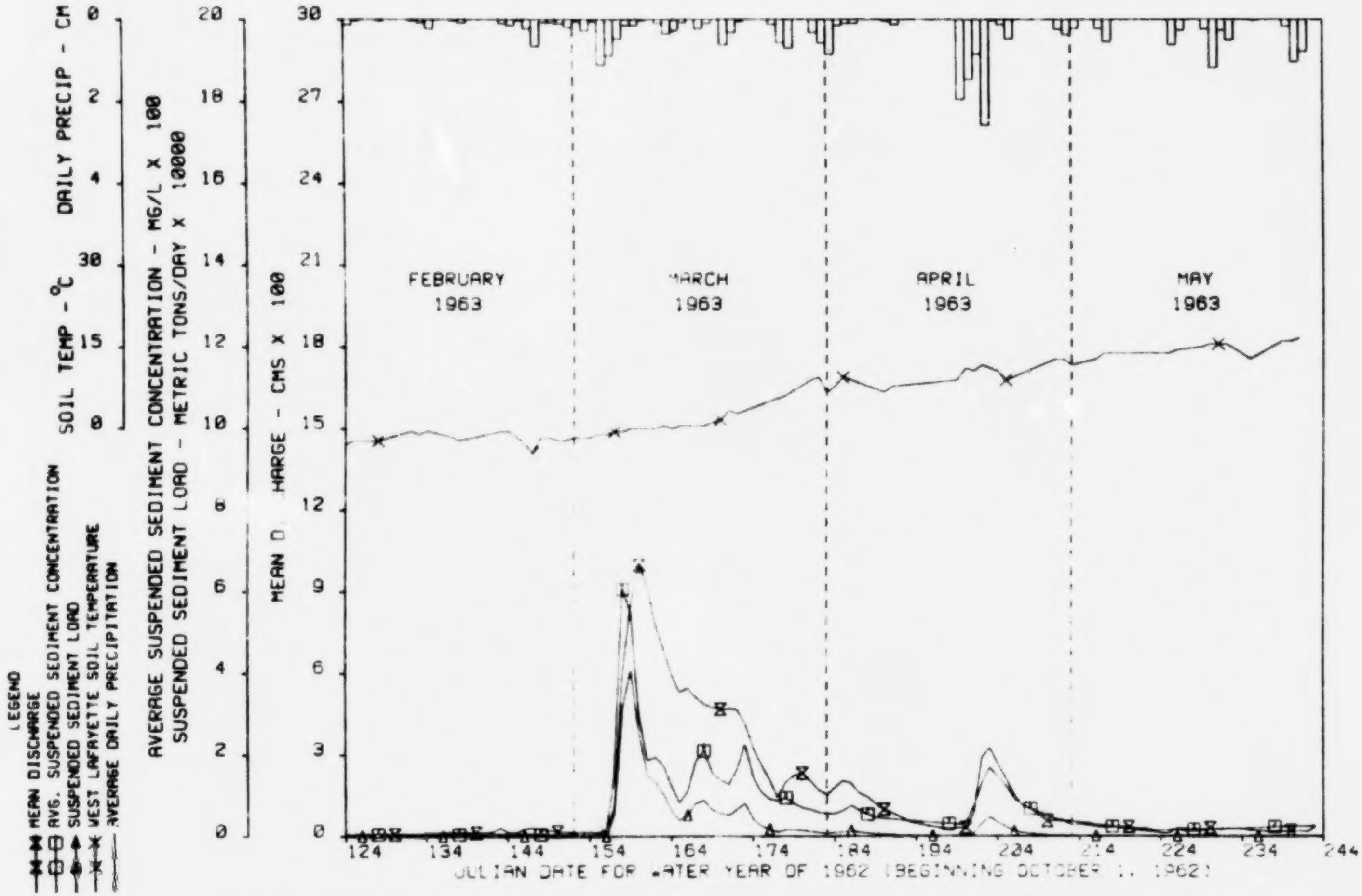


**Figure 7.26 Sediment Load and Related Parameters for the Maumee River from February, 1963, to May, 1963**

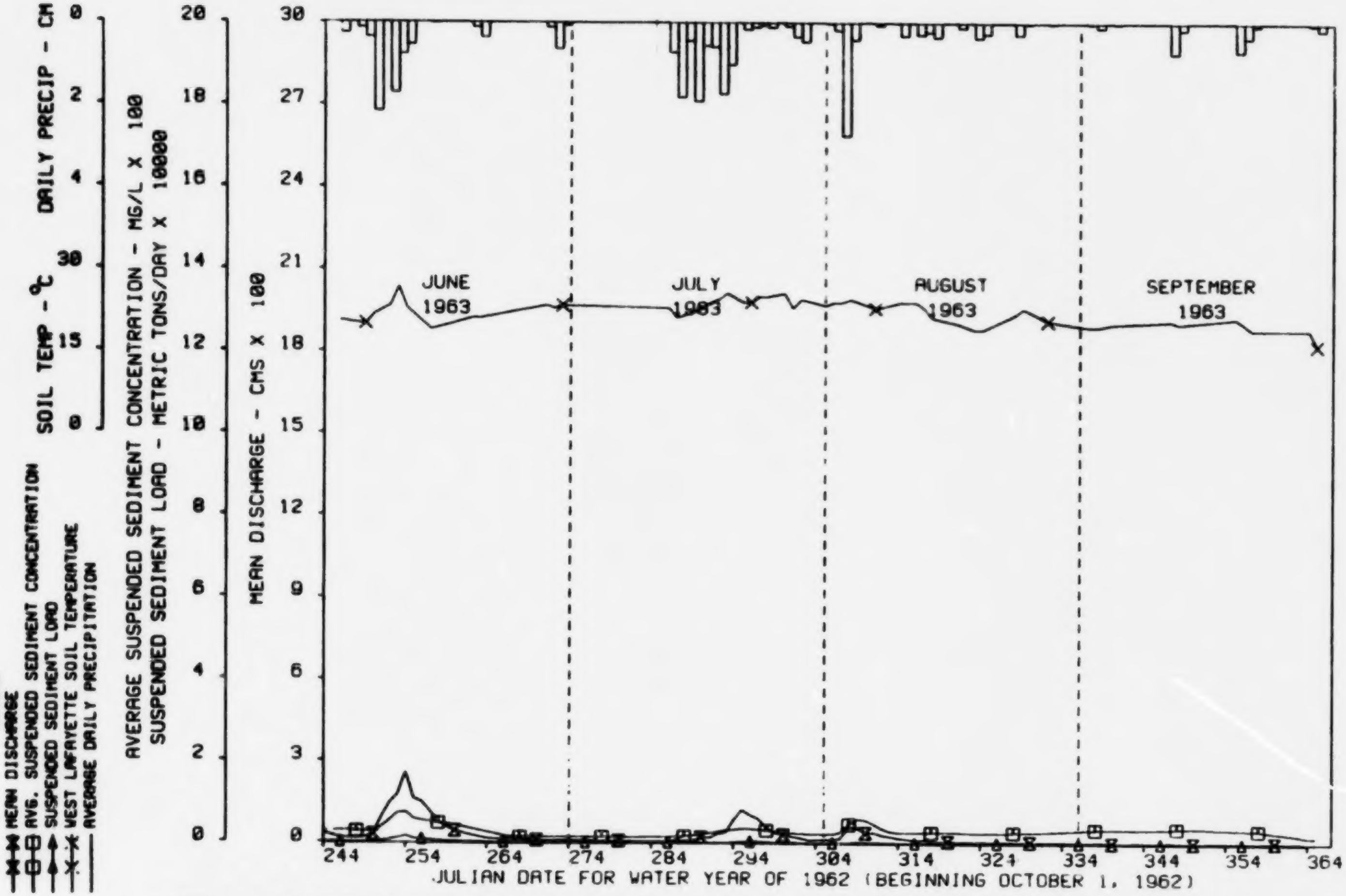


**Figure 7.27 Sediment Load and Related Parameters for the Maumee River from June, 1963 to September, 1963**

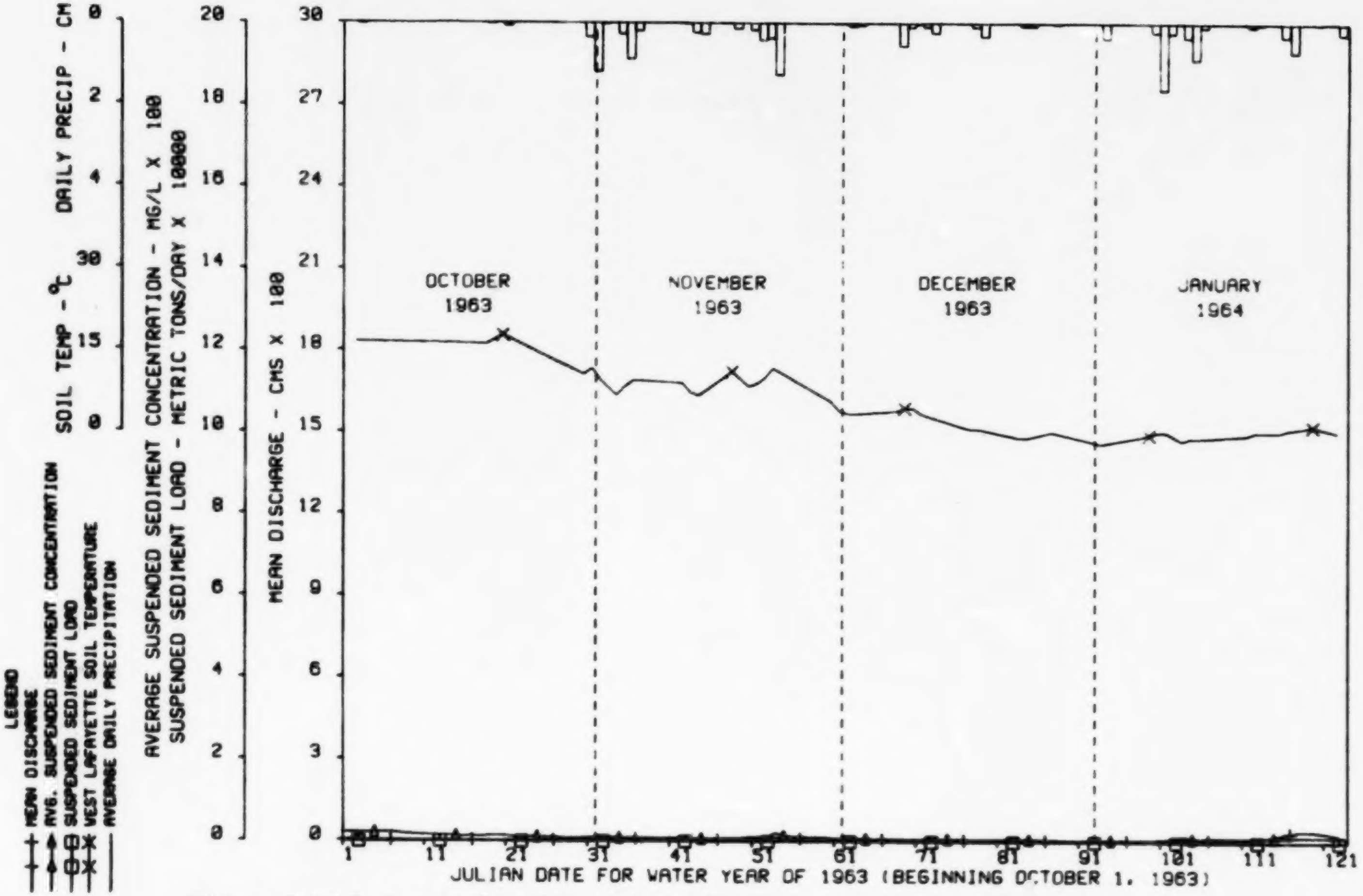


**Figure 7.28** Sediment Load and Related Parameters for the Maumee River from October, 1963, to January, 1964

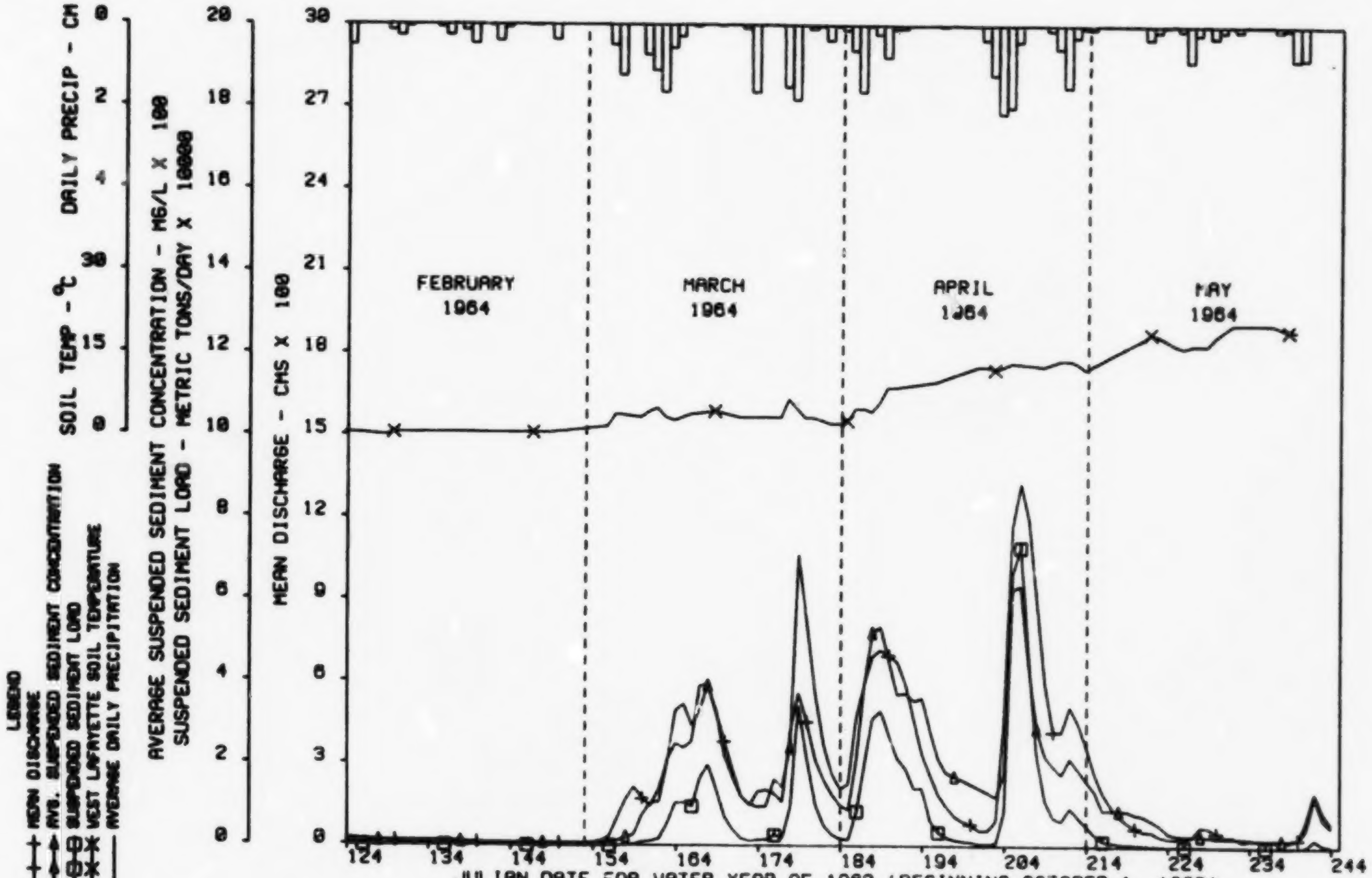


Figure 7.29 Sediment Load and Related Parameters for the Maumee River from February, 1964, to May, 1964

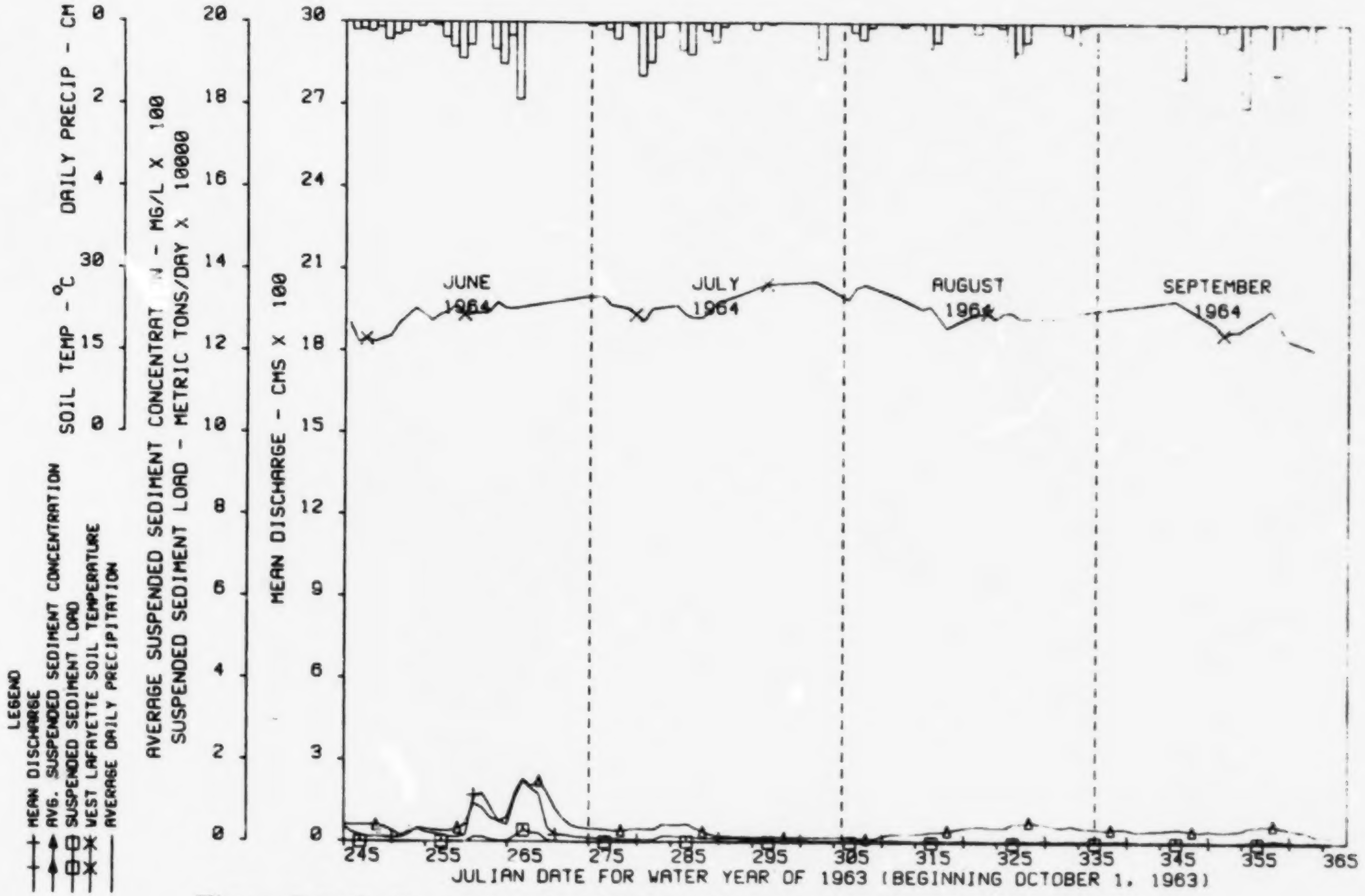


Figure 7.30 Sediment Load and Related Parameters for the Maumee River from June, 1964, to September, 1964

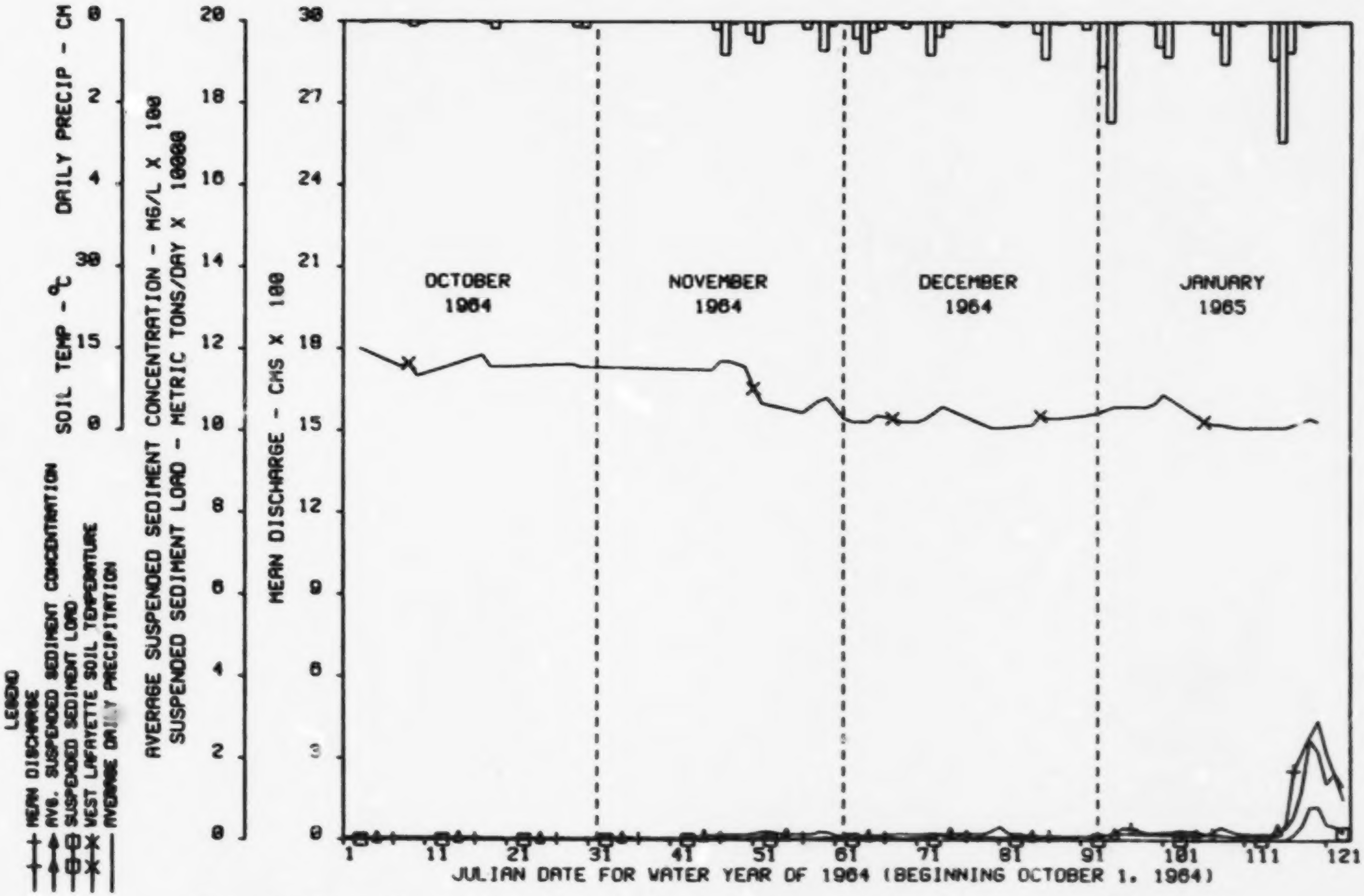


Figure 7.31 Sediment Load and Related Parameters for the Maumee River from October, 1964, to January, 1964

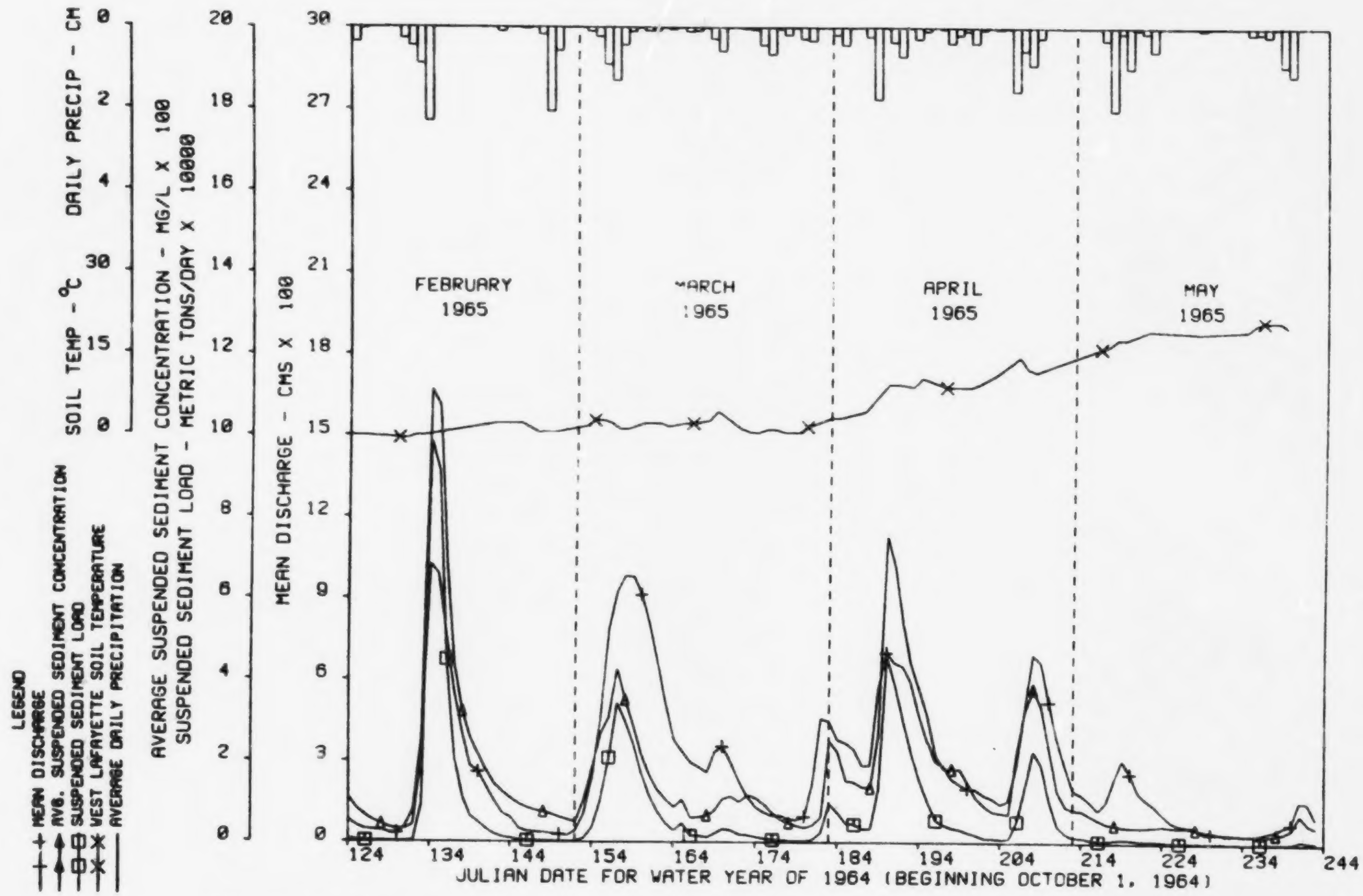


Figure 7.32 Sediment Load and Related Parameters for the Maumee River from February, 1965, to May, 1965

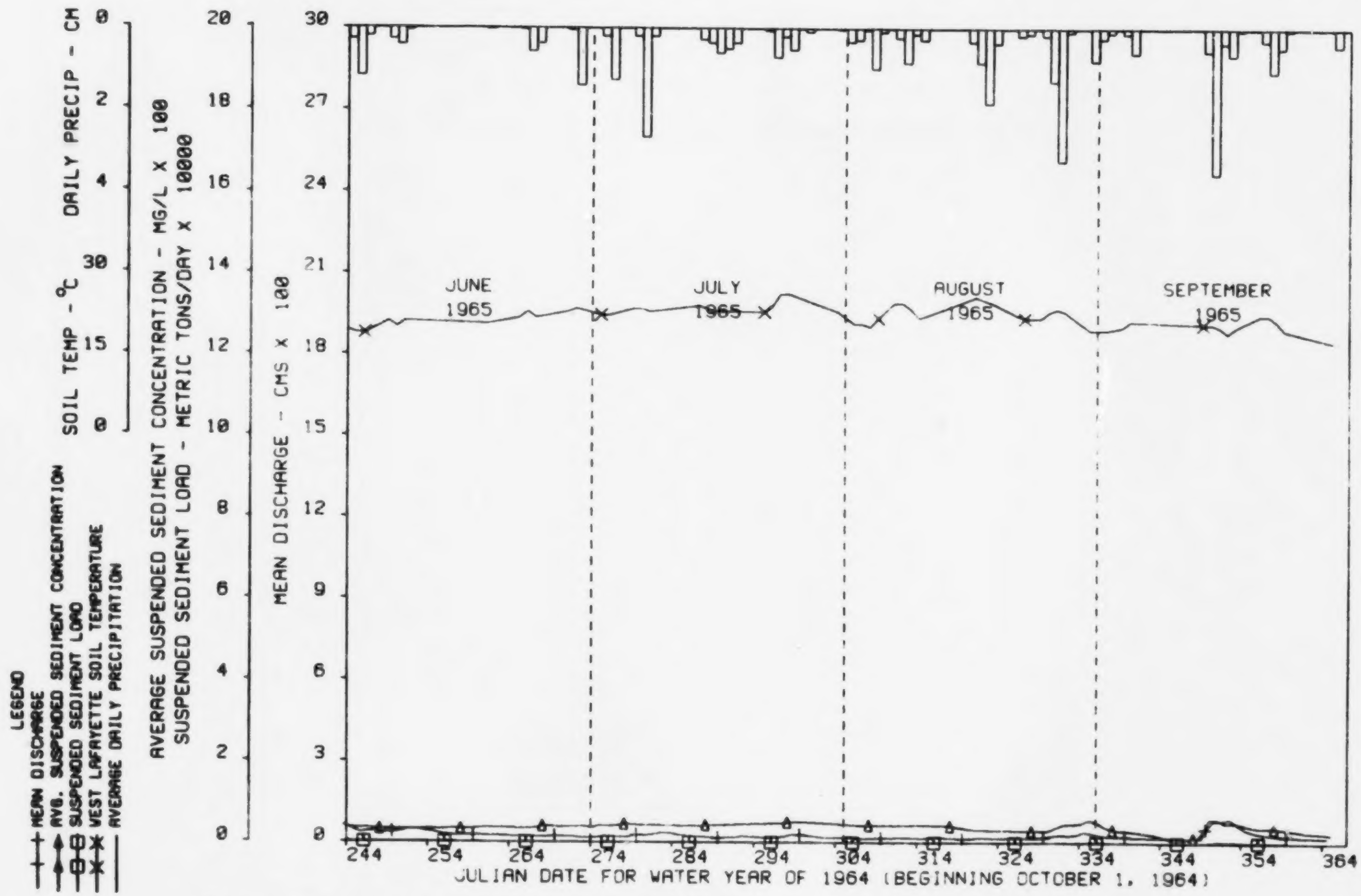


**Figure 7.33 Sediment Load and Related Parameters for the Maumee River from June, 1965, to September, 1965**

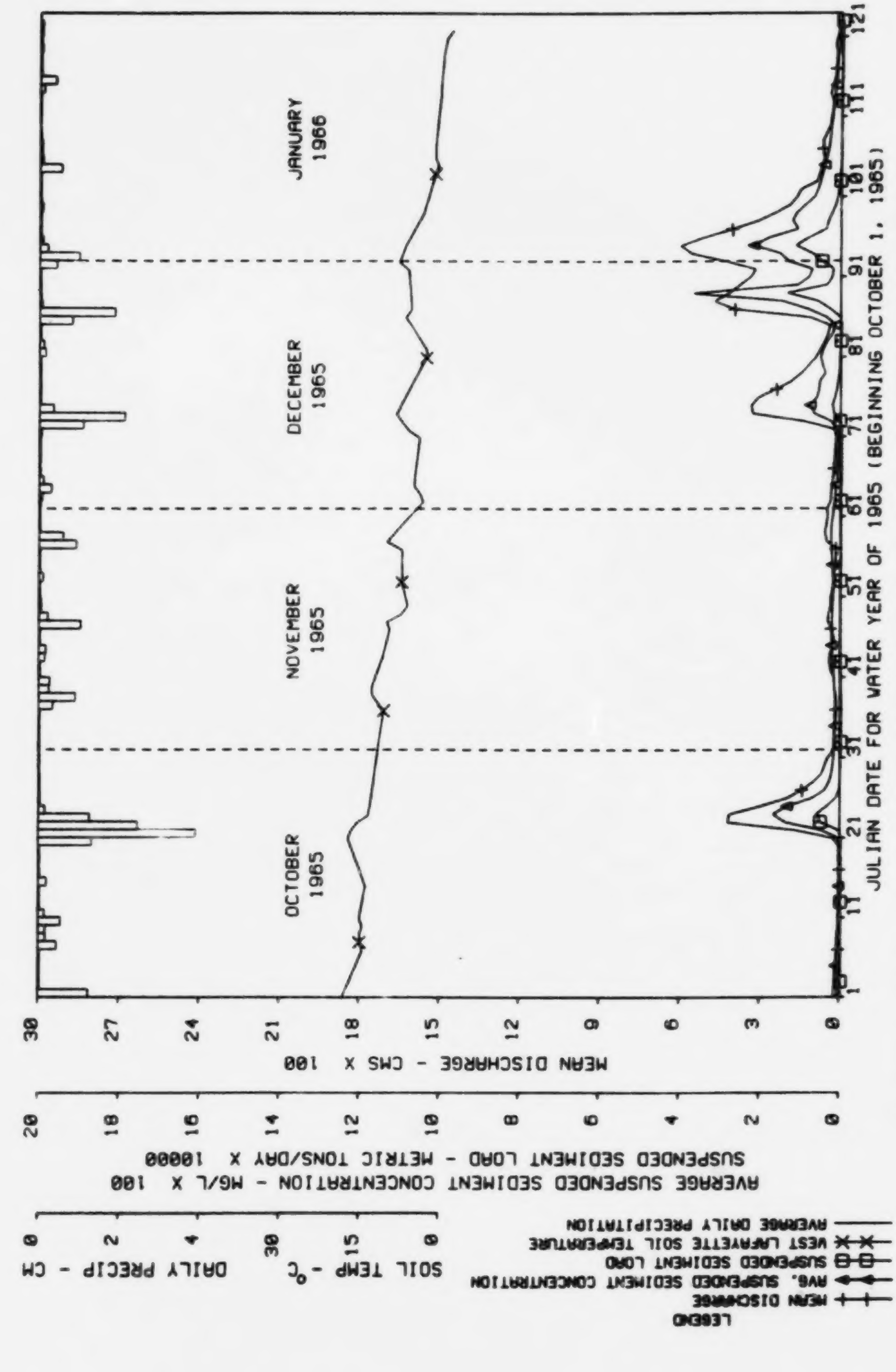


Figure 7.34 Sediment Load and Related Parameters for the Maumee River from October, 1965, to January, 1966

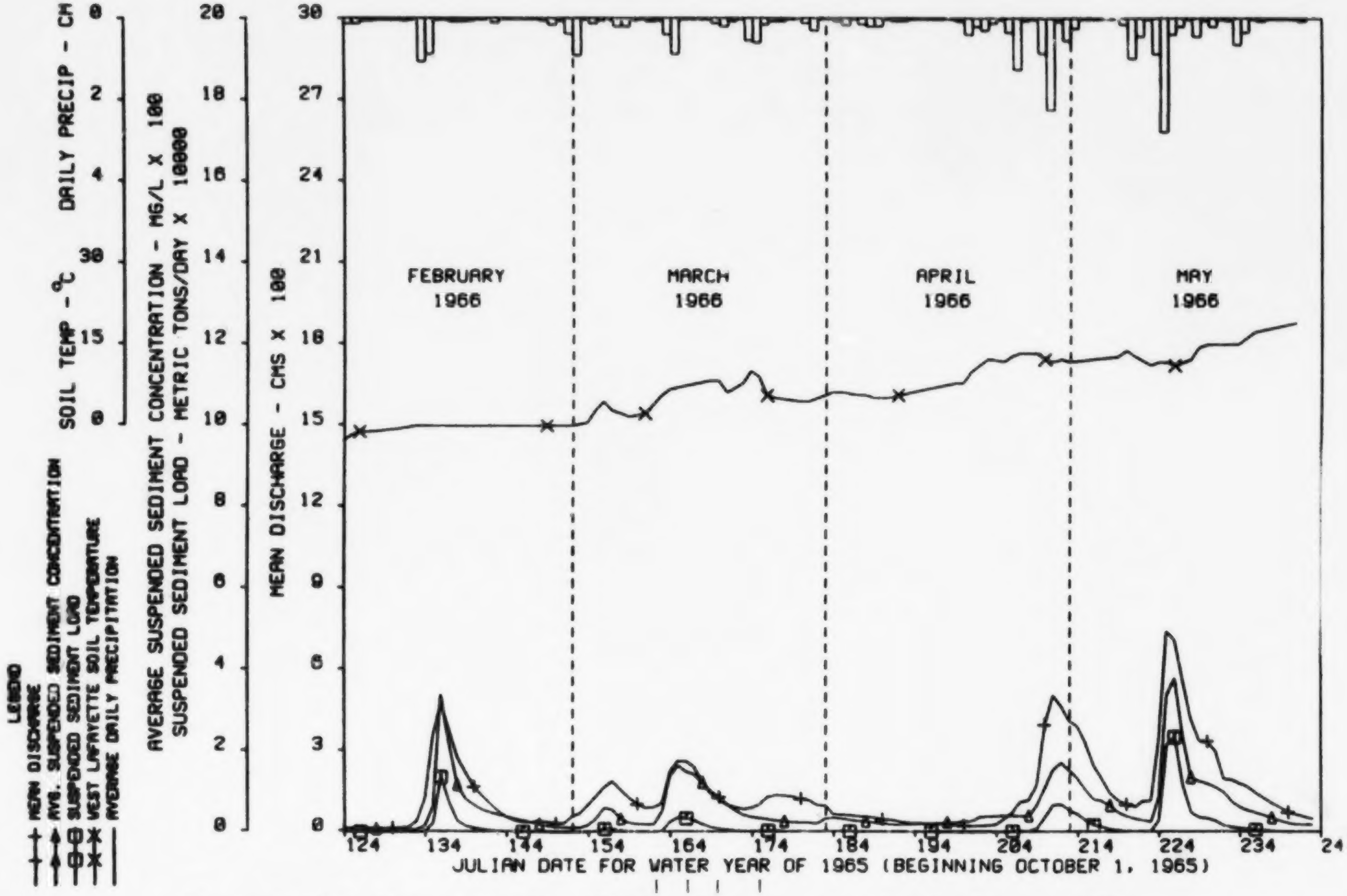


Figure 7.35 Sediment Load and Related Parameters for the Maumee River from February, 1966, to May, 1966

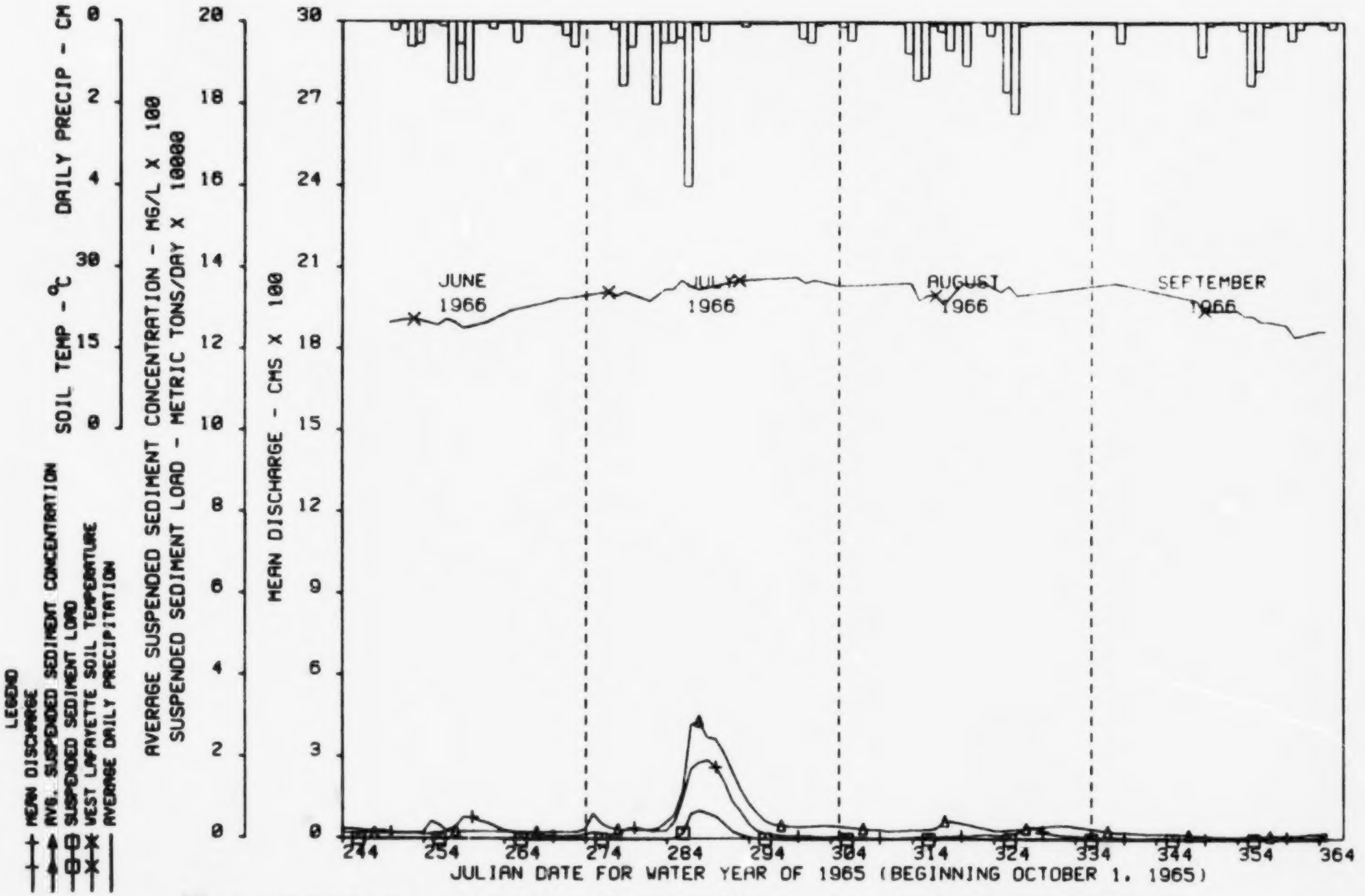


**Figure 7.36** Sediment Load and Related Parameters for the Maumee River from June, 1966, to September, 1966

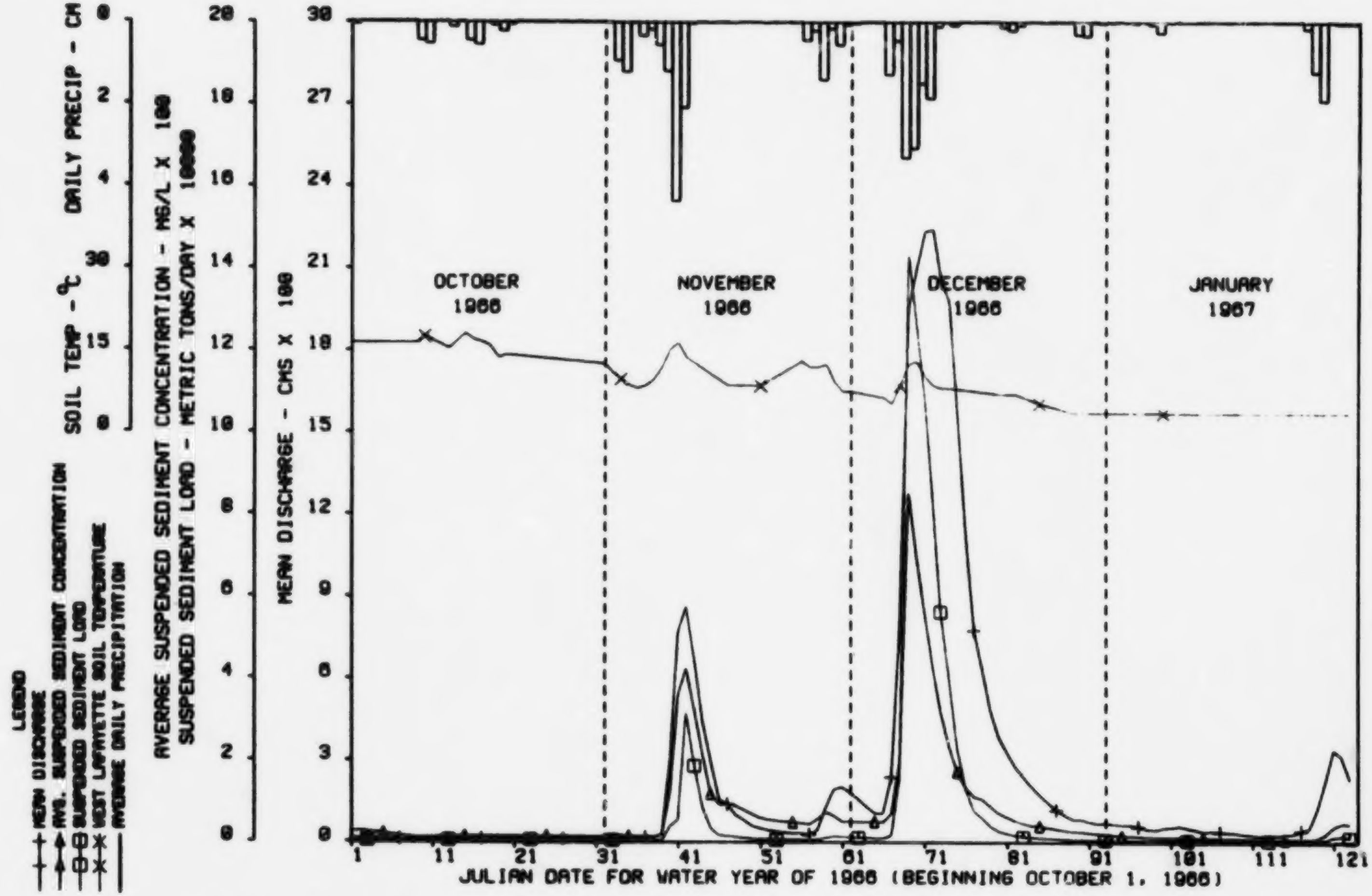


**Figure 7.37 Sediment Load and Related Parameters for the Maumee River from October, 1966, to January, 1967**

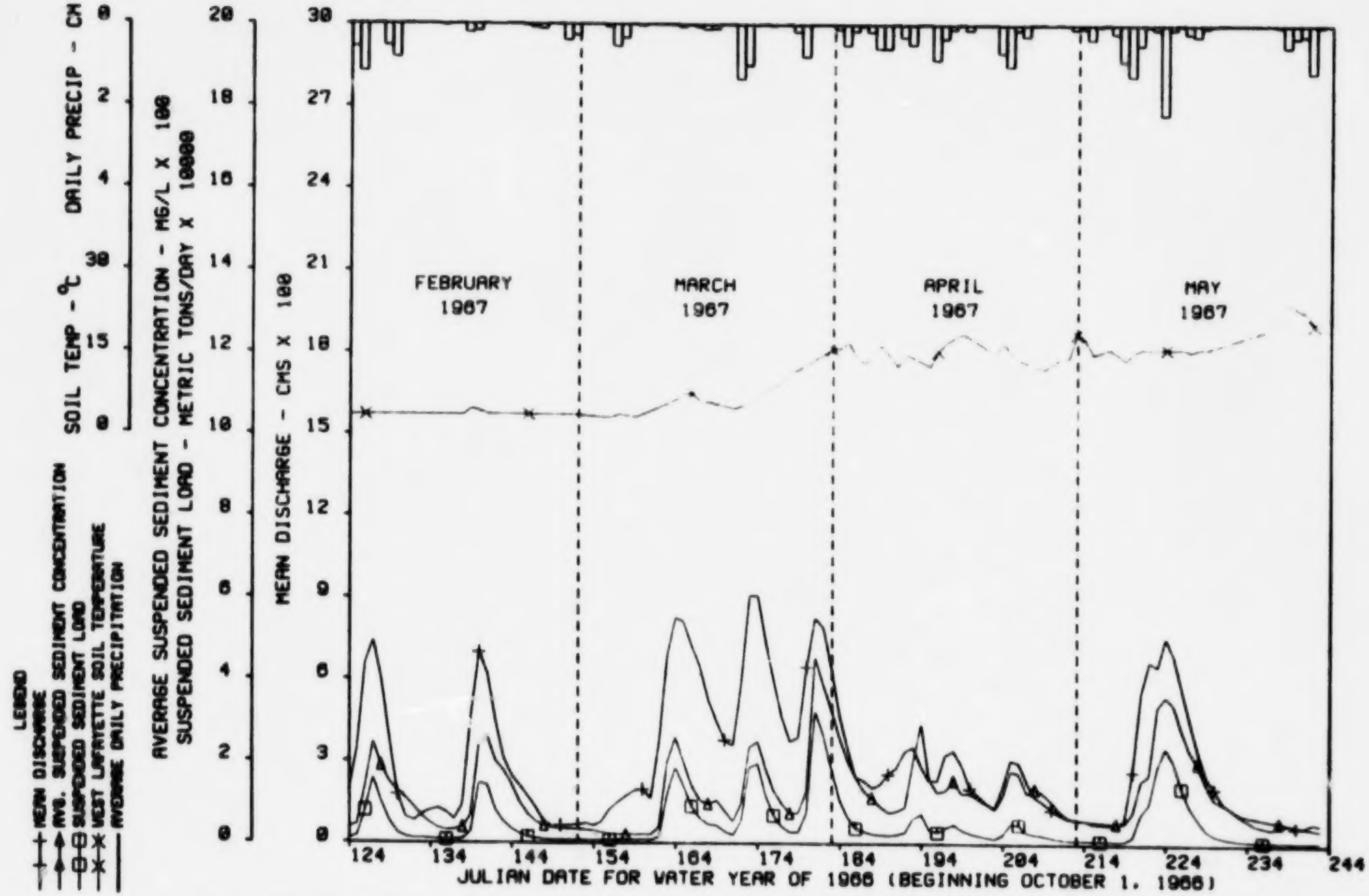


**Figure 7.38 Sediment Load and Related Parameters for the Maumee River from February, 1967, to May, 1967**

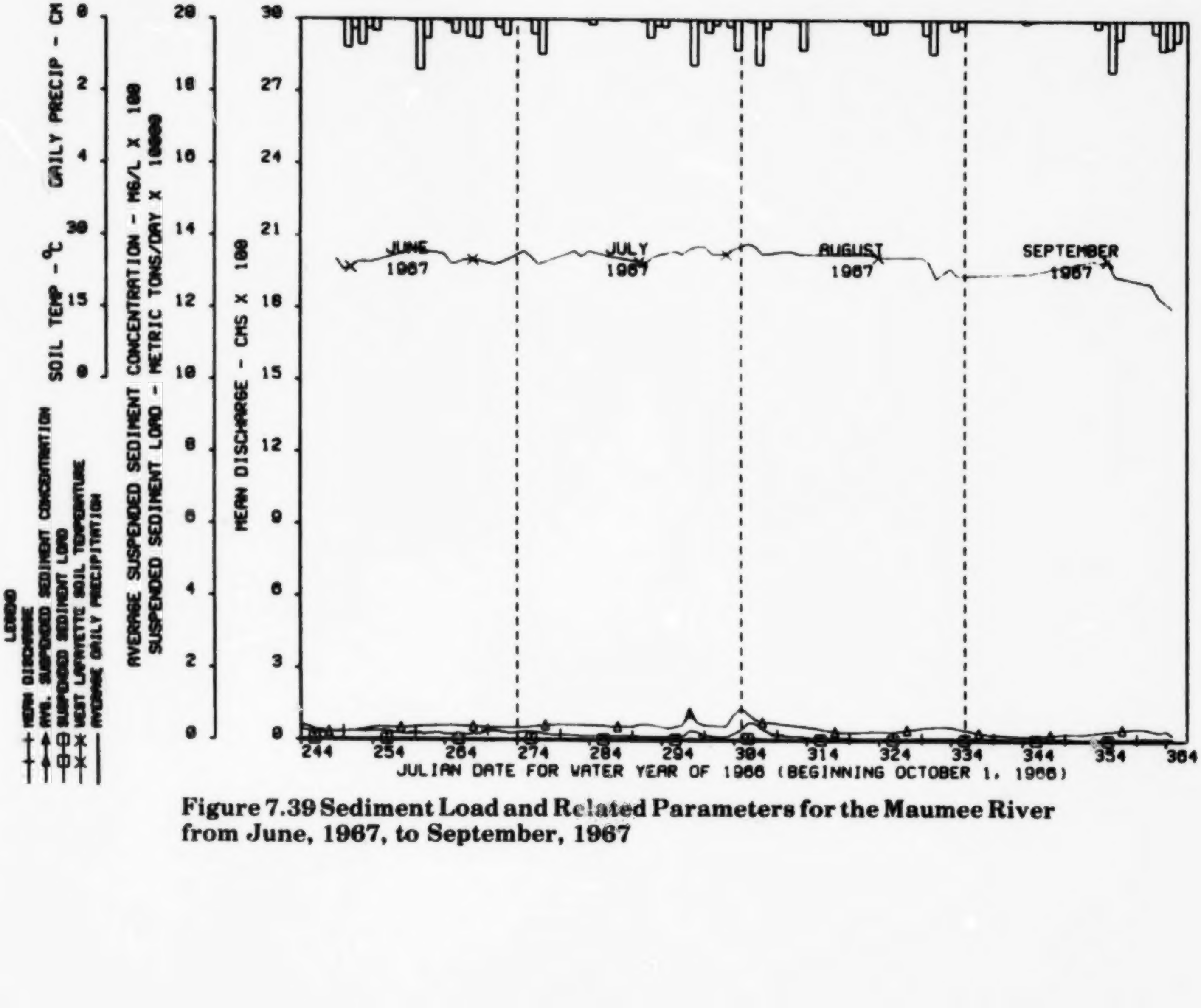


Figure 7.39 Sediment Load and Related Parameters for the Maumee River from June, 1967, to September, 1967

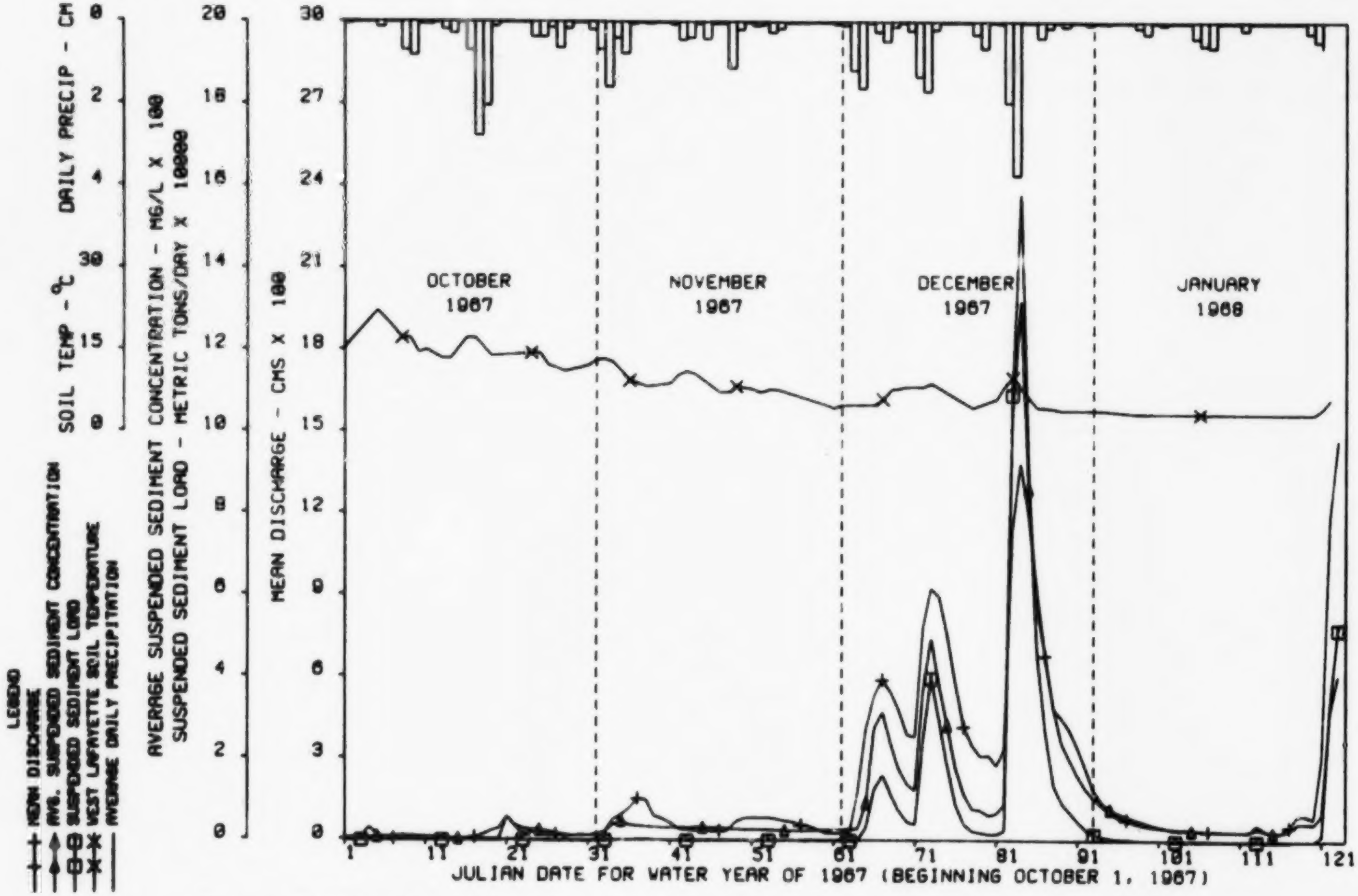


Figure 7.40 Sediment Load and Related Parameters for the Maumee River from October, 1967, to January, 1968

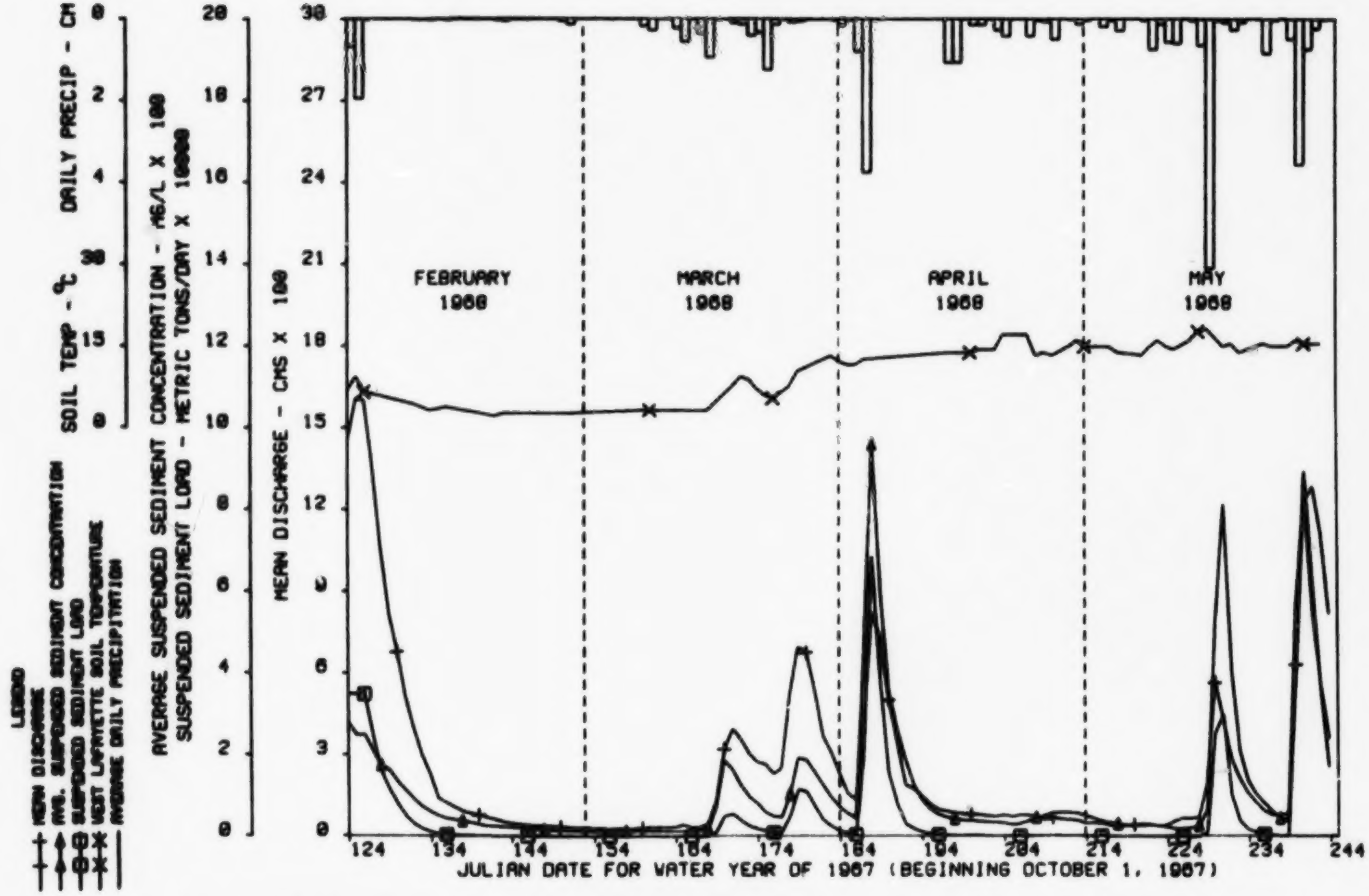


Figure 7.41 Sediment Load and Related Parameters for the Maumee River from February, 1968, to May, 1968

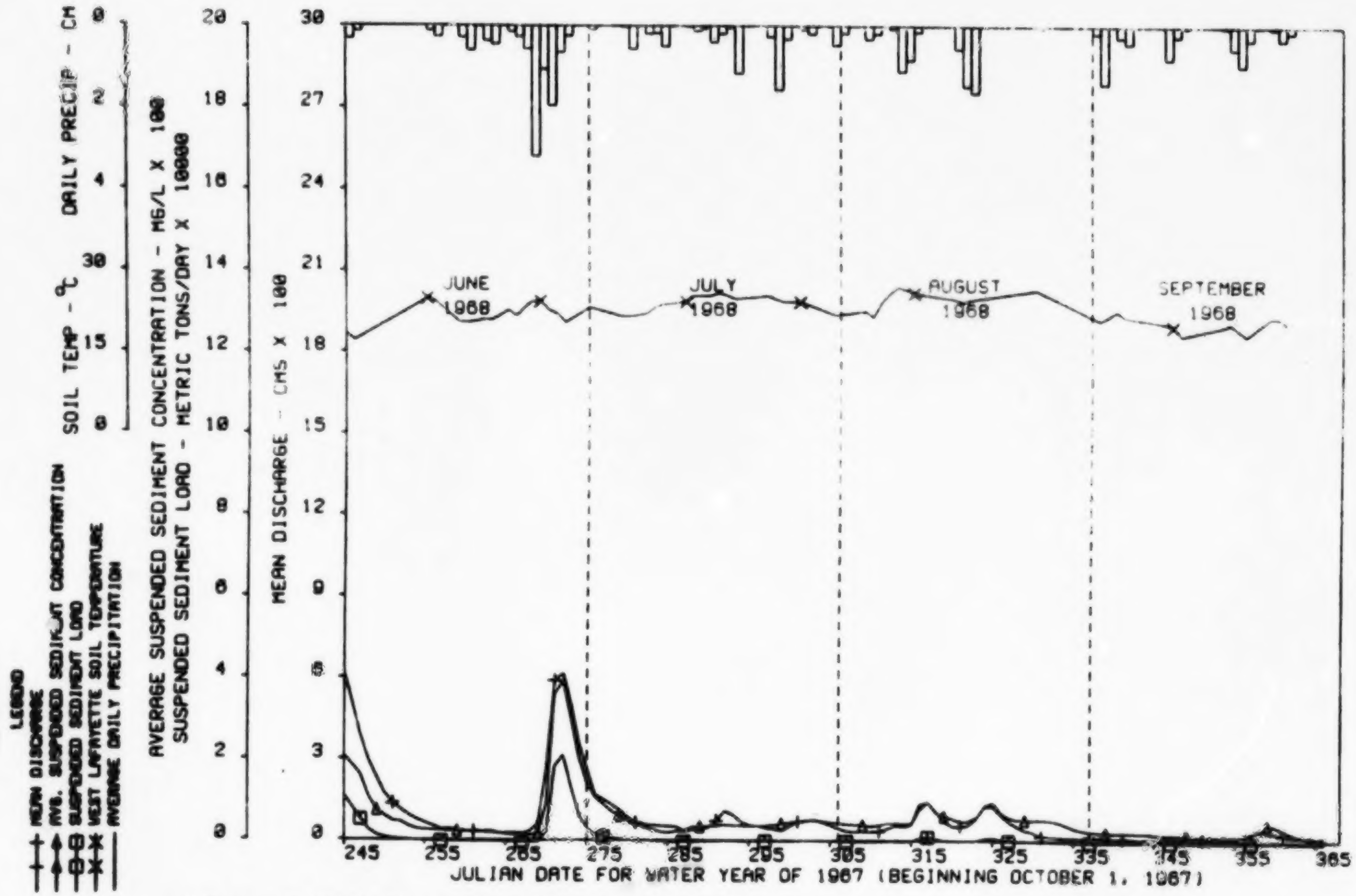


Figure 7.42 Sediment Load and Related Parameters for the Maumee River from June, 1968, to September, 1968

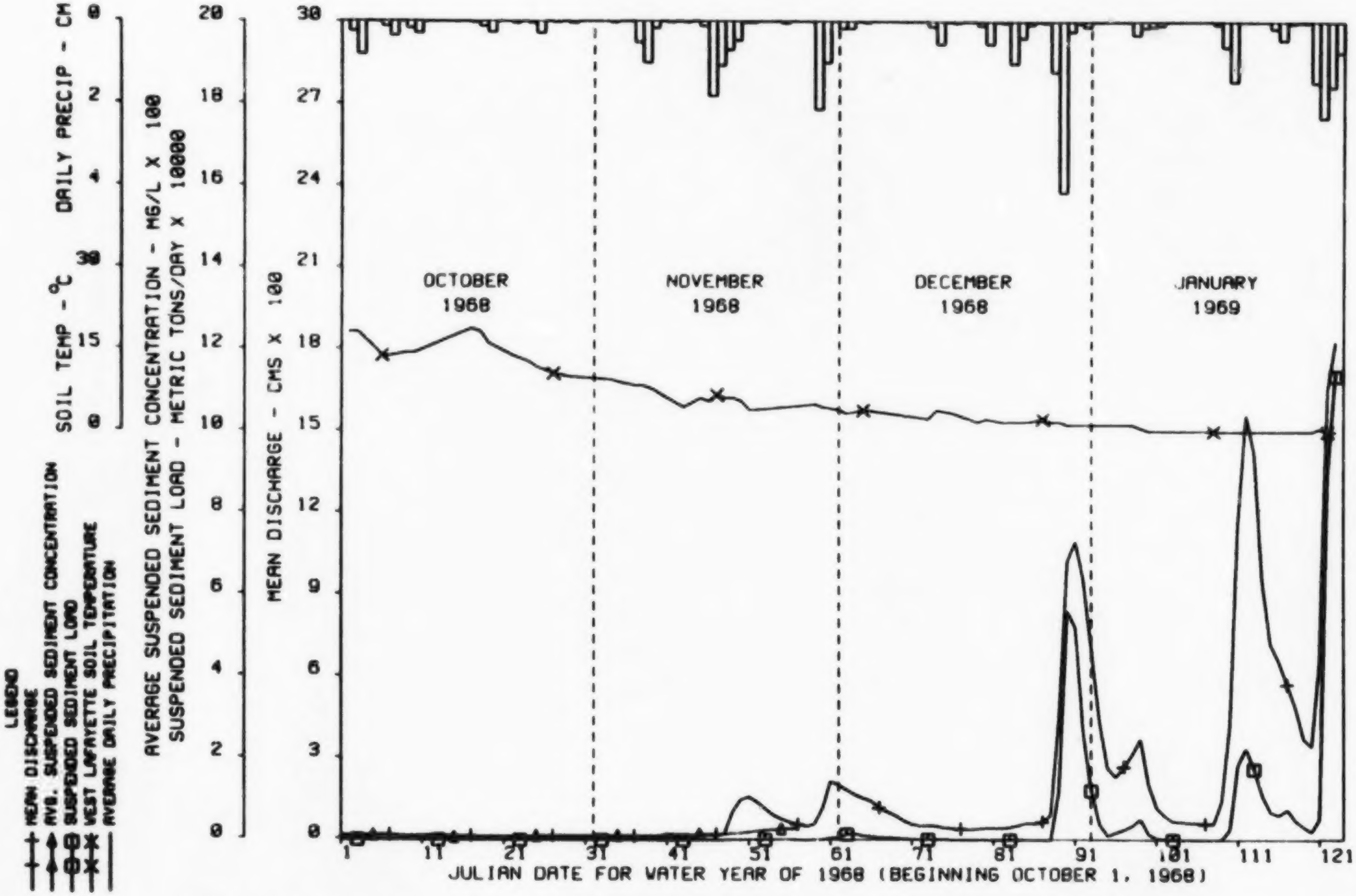


Figure 7.43 Sediment Load and Related Parameters for the Maumee River from October, 1968, to January, 1969

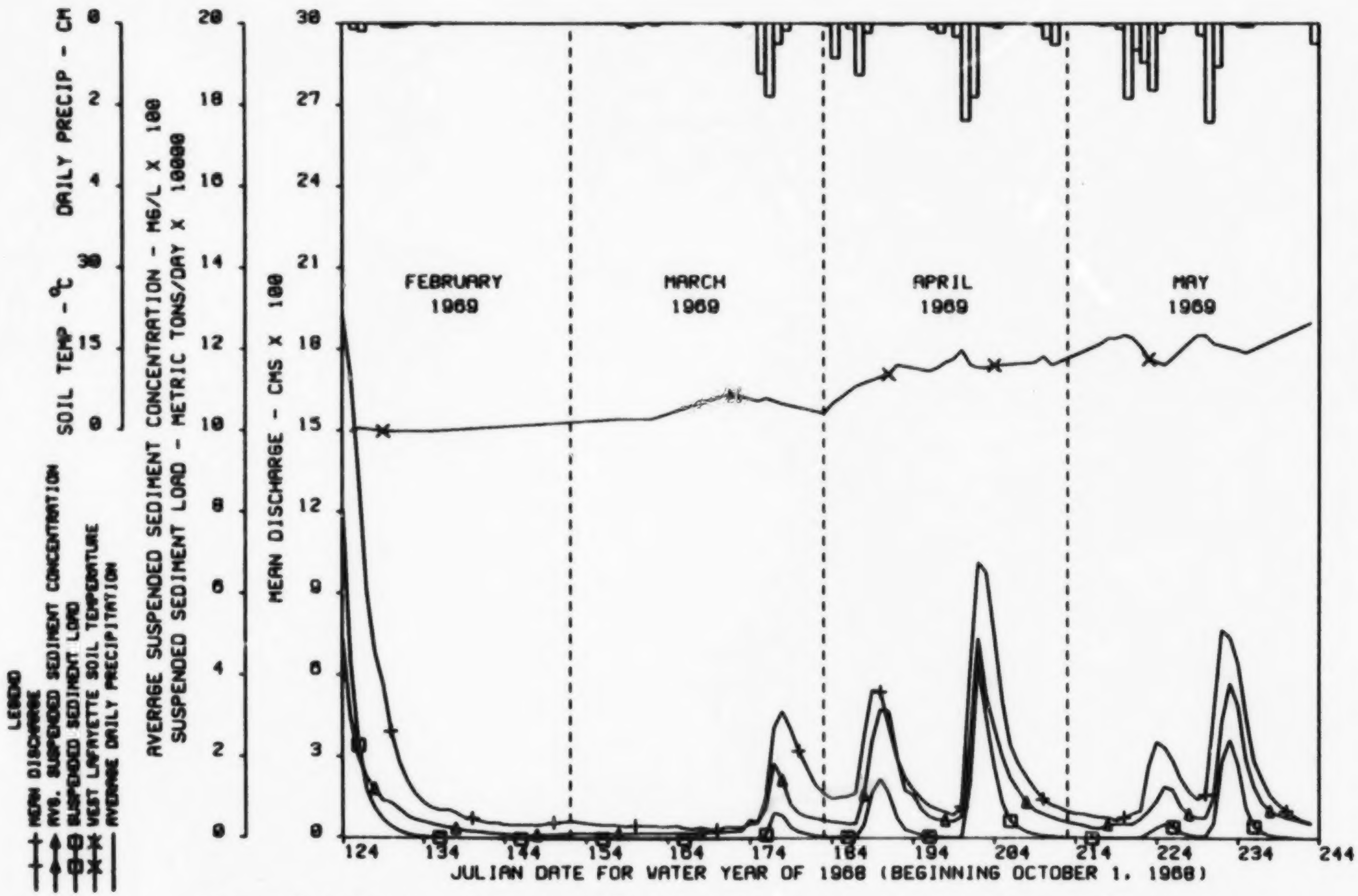


Figure 7.44 Sediment Load and Related Parameters for the Maumee River from February, 1969, to May, 1969

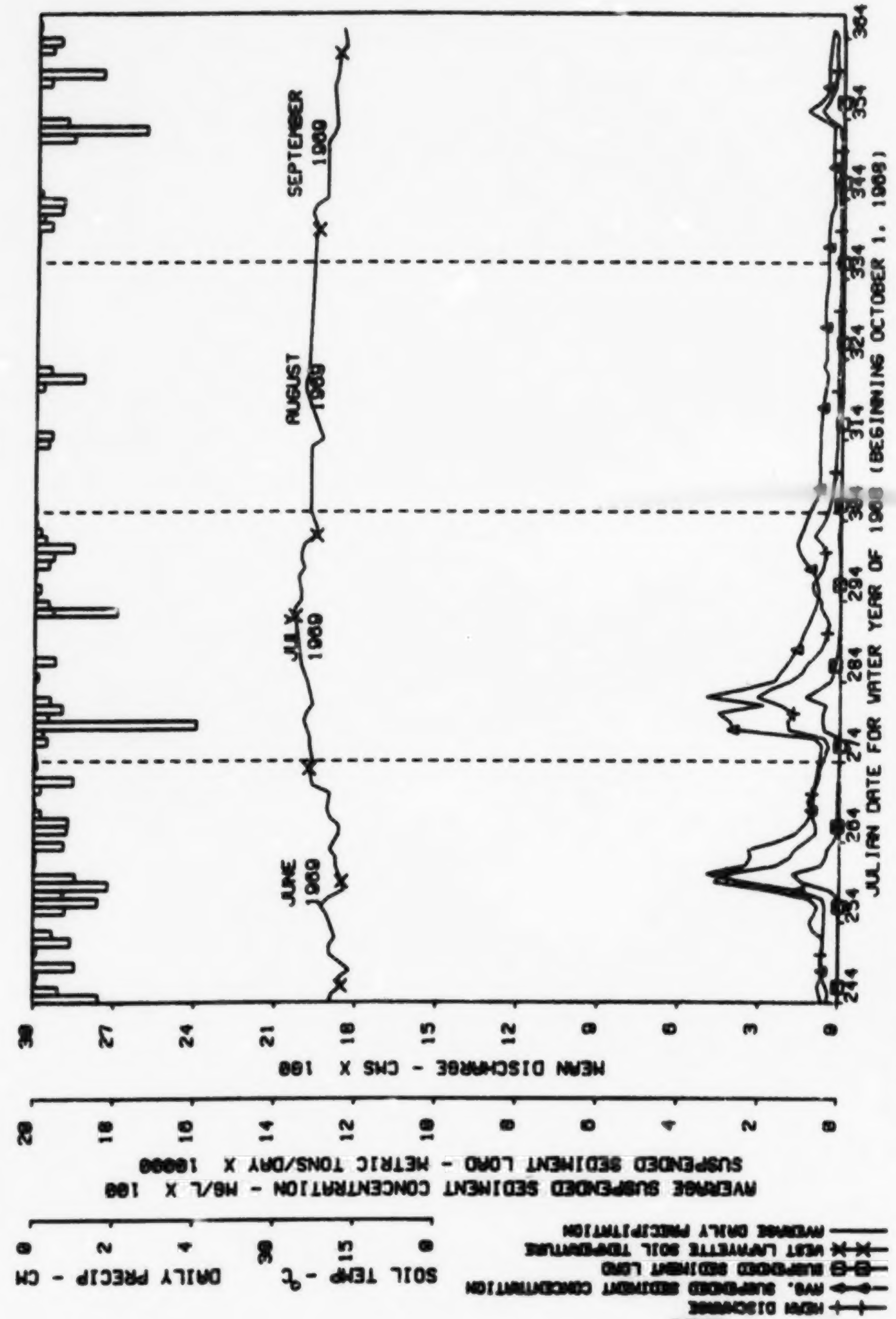


Figure 7.45 Sediment Load and Related Parameters for the Maumee River from June, 1969, to September, 1969

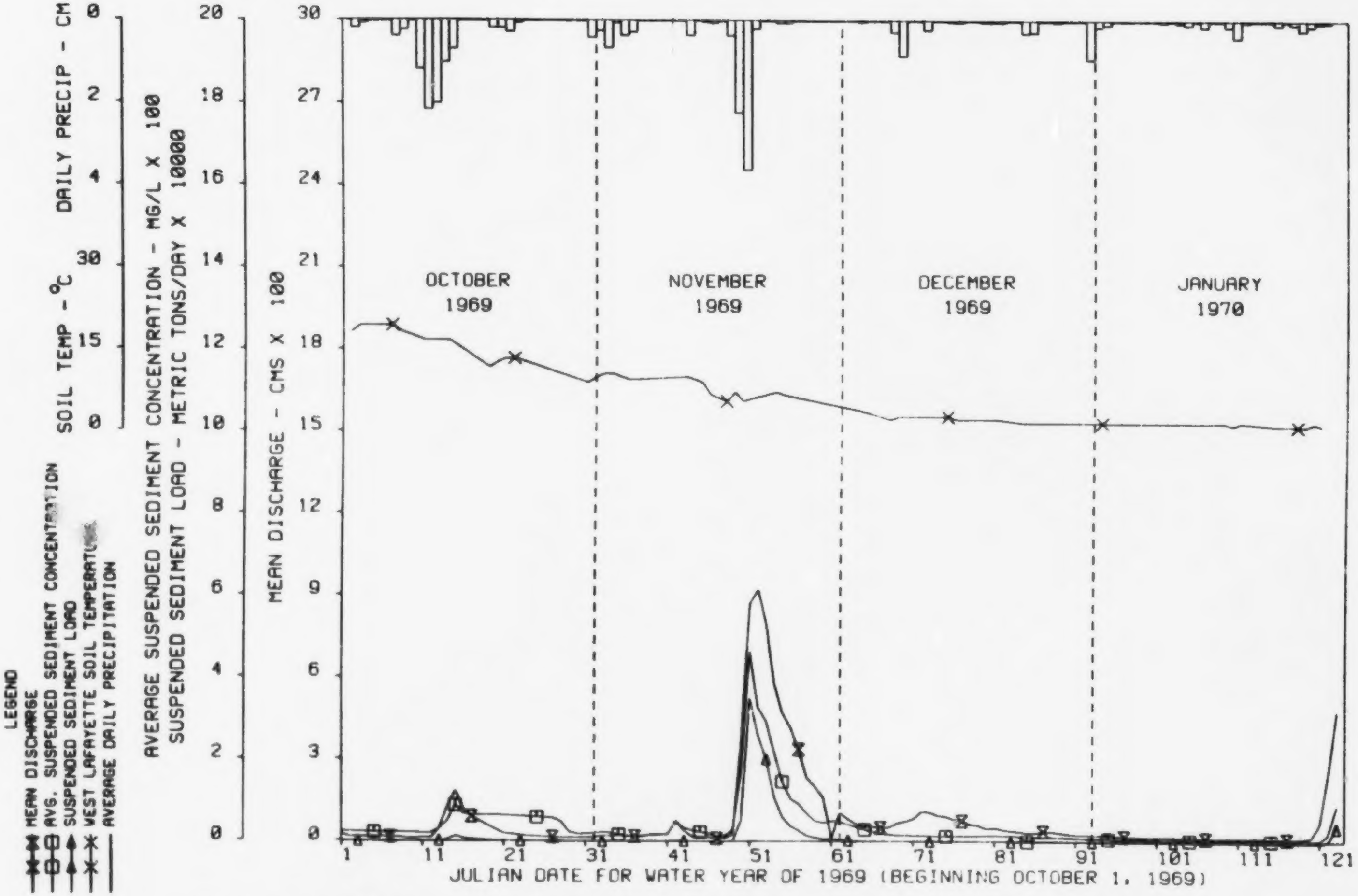


Figure 7.46 Sediment Load and Related Parameters for the Maumee River from October, 1969, to January, 1970

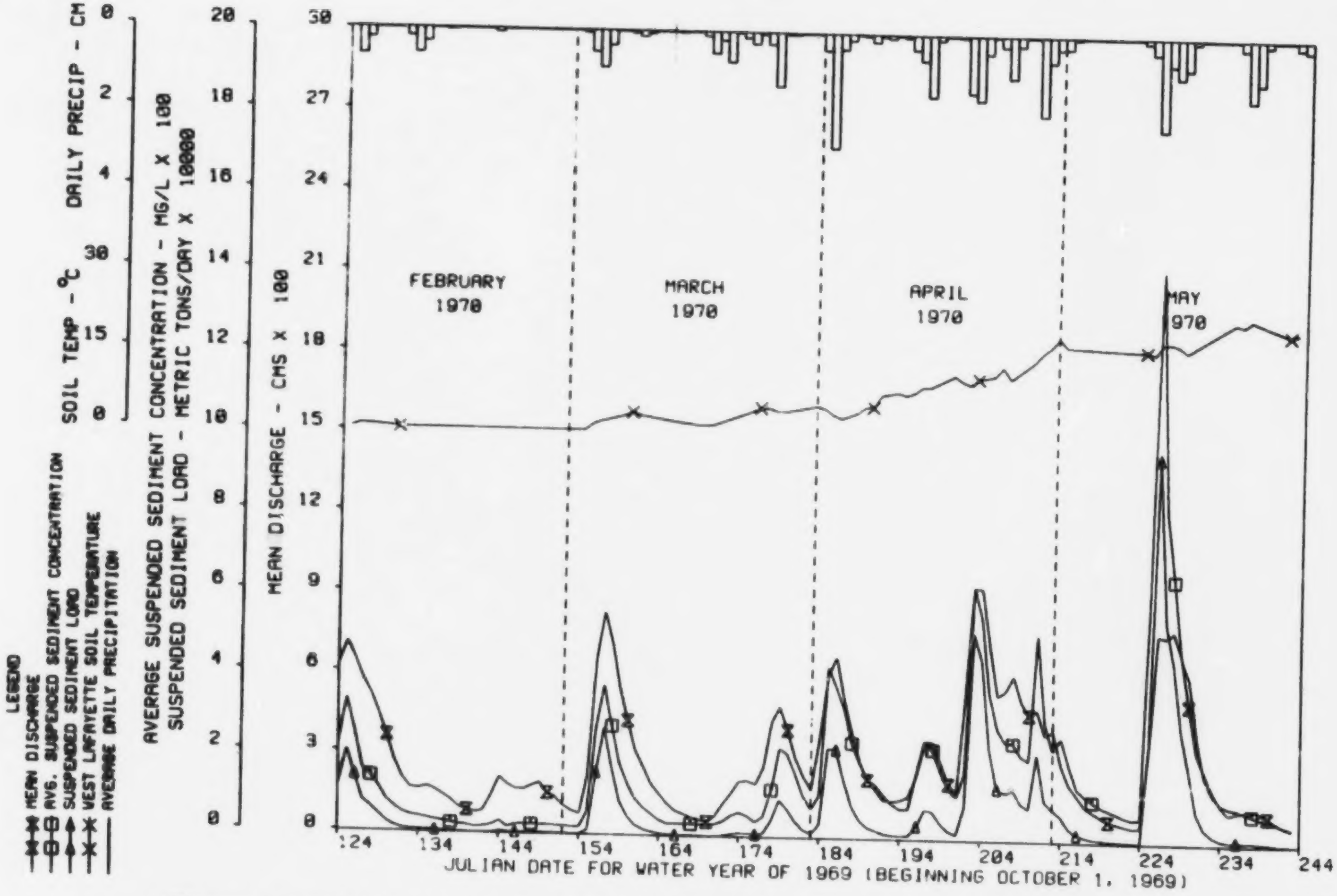


Figure 7.47 Sediment Load and Related Parameters for the Maumee River from February, 1970, to May, 1970

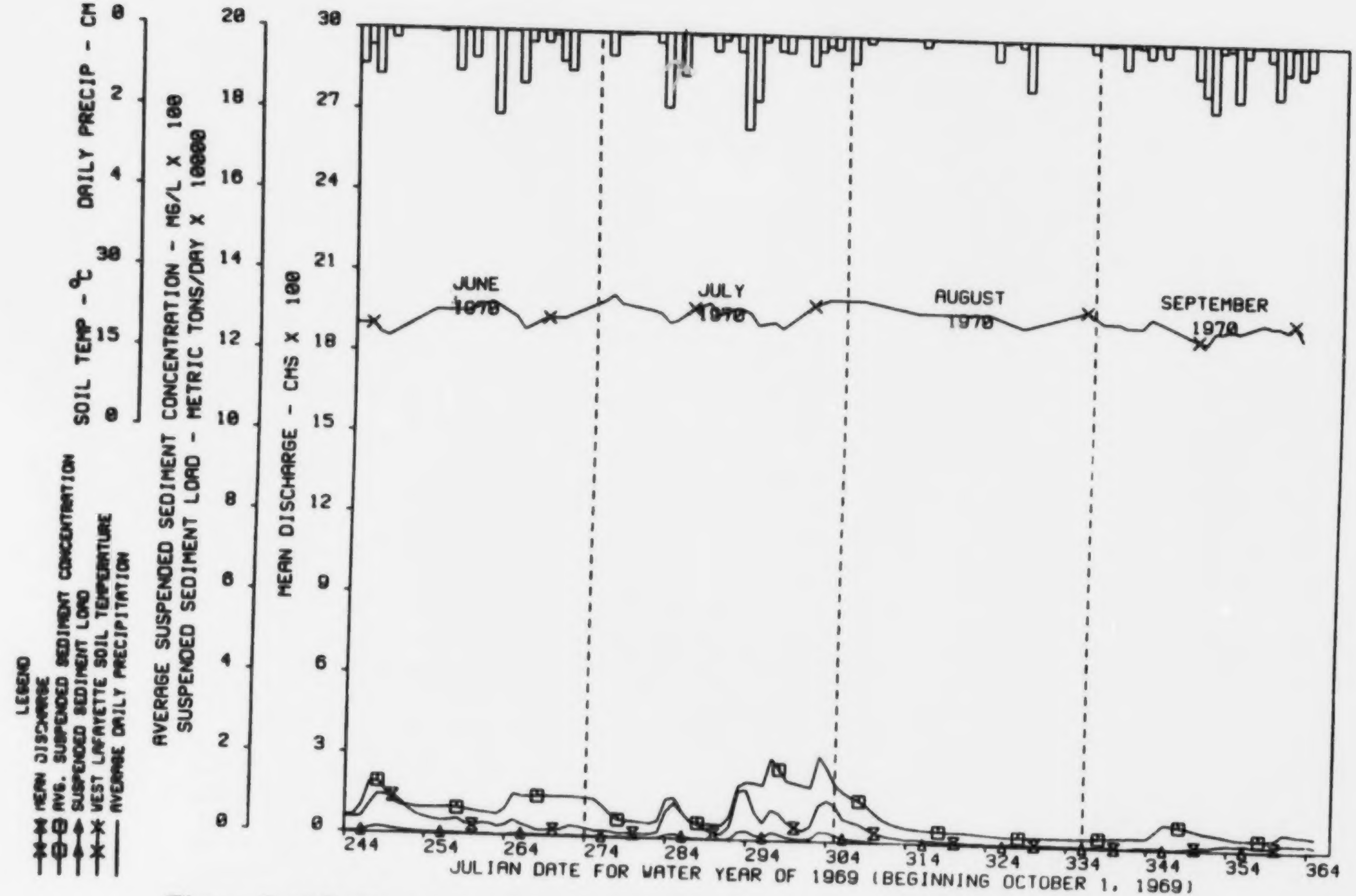


Figure 7.48 Sediment Load and Related Parameters for the Maumee River from June, 1970, to September, 1970

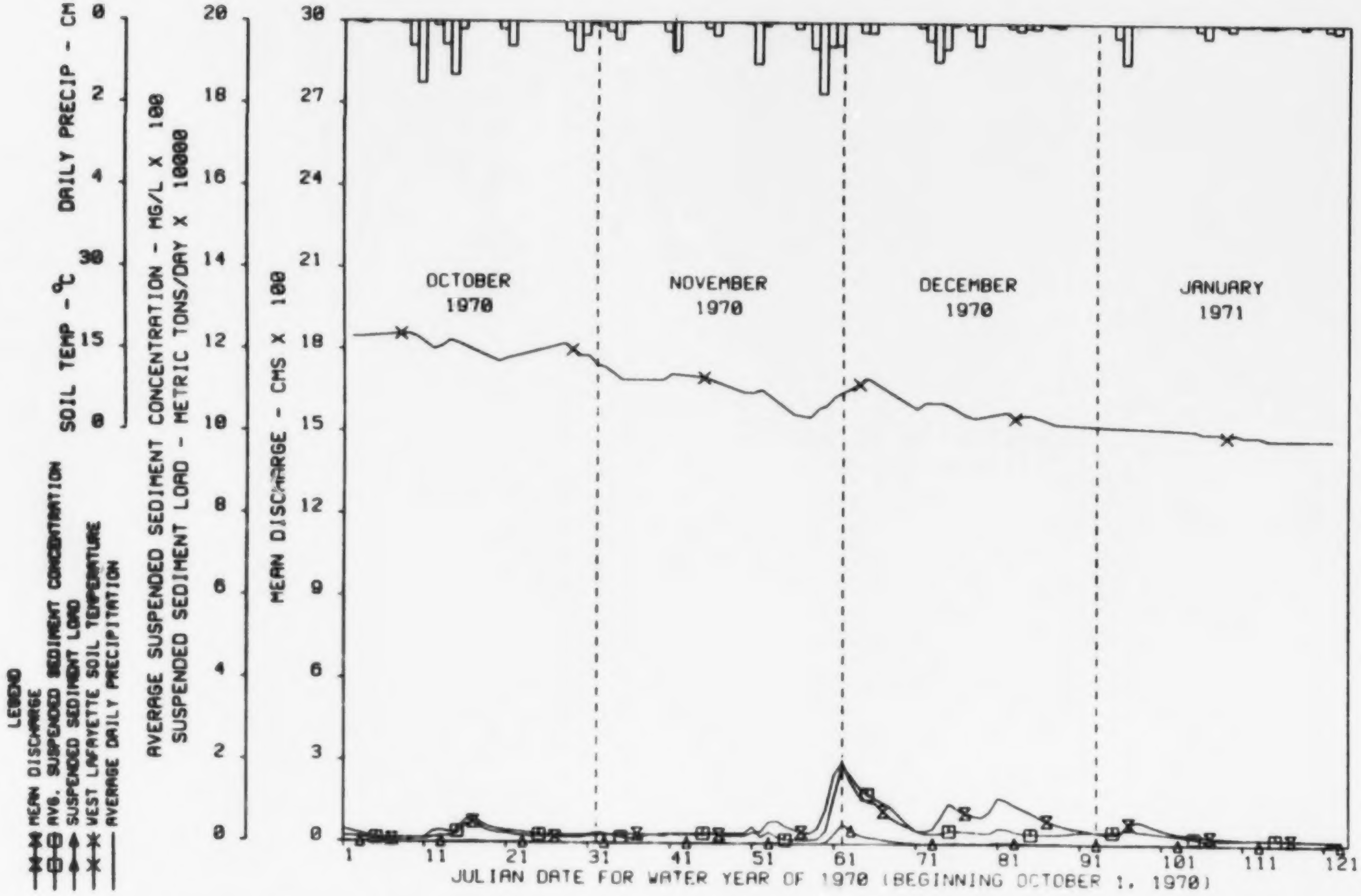


Figure 7.49 Sediment Load and Related Parameters for the Maumee River from October, 1970, to January, 1971

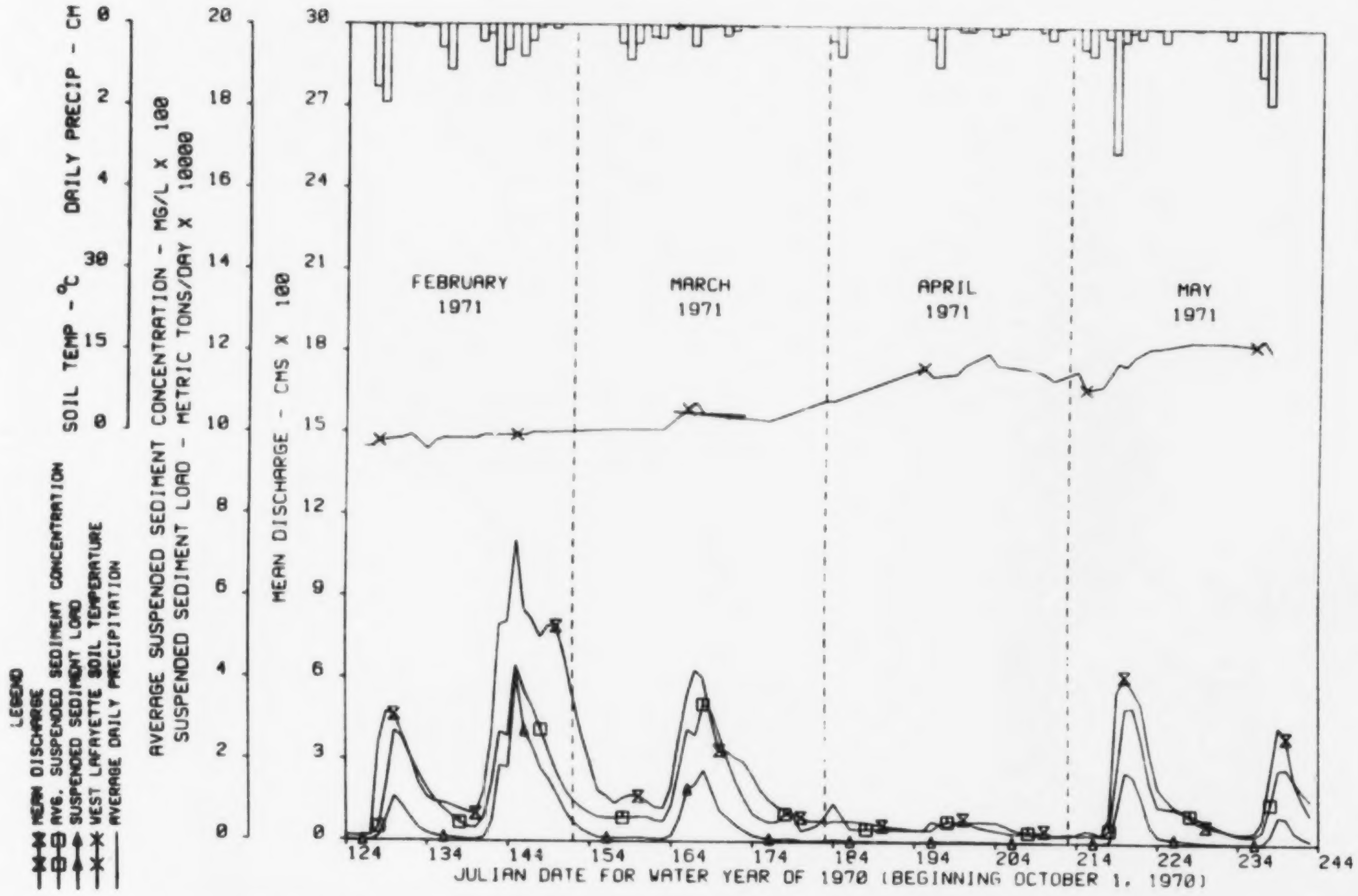


**Figure 7.50 Sediment Load and Related Parameters for the Maumee River from February, 1971, to May, 1971**

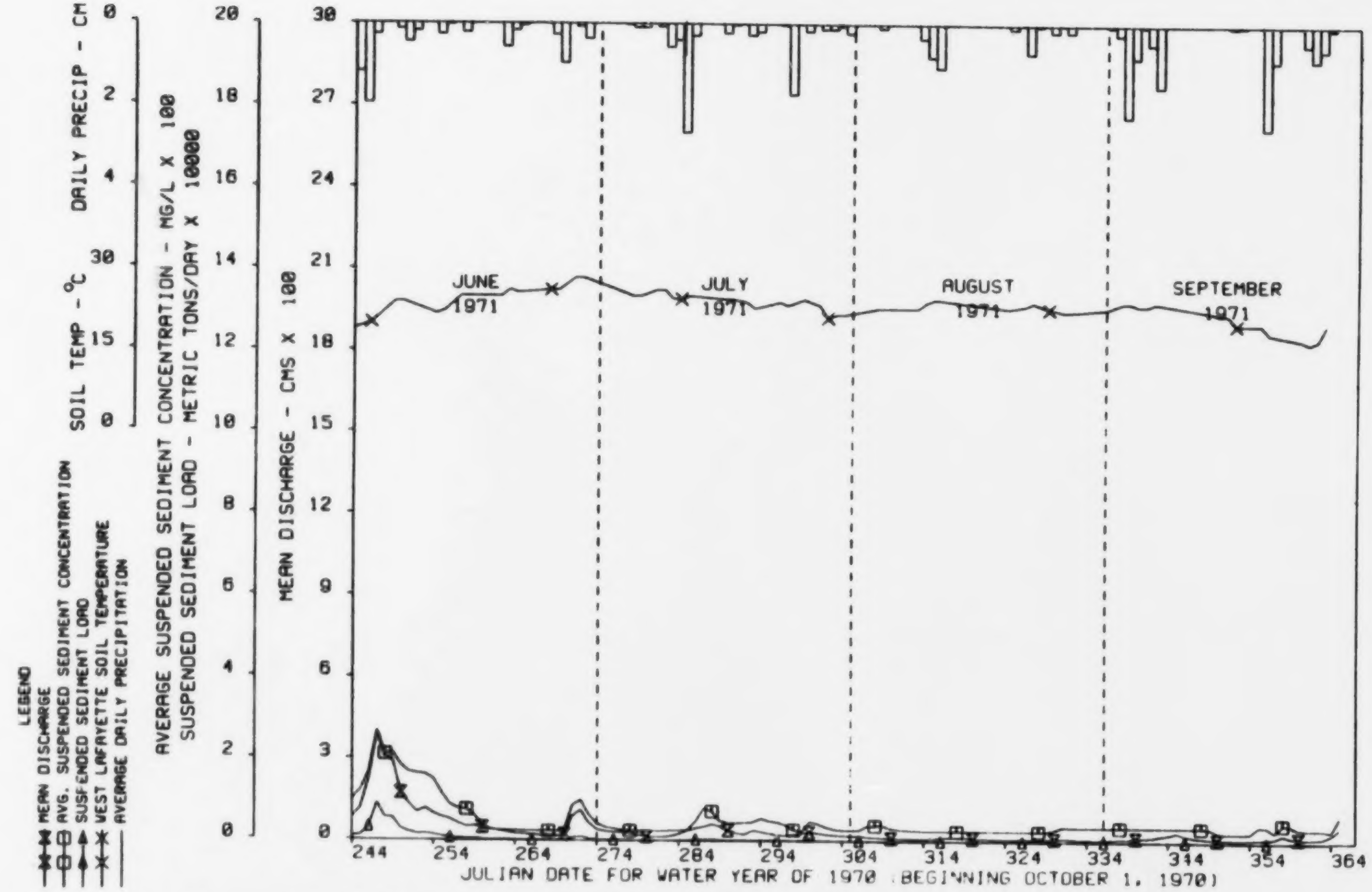
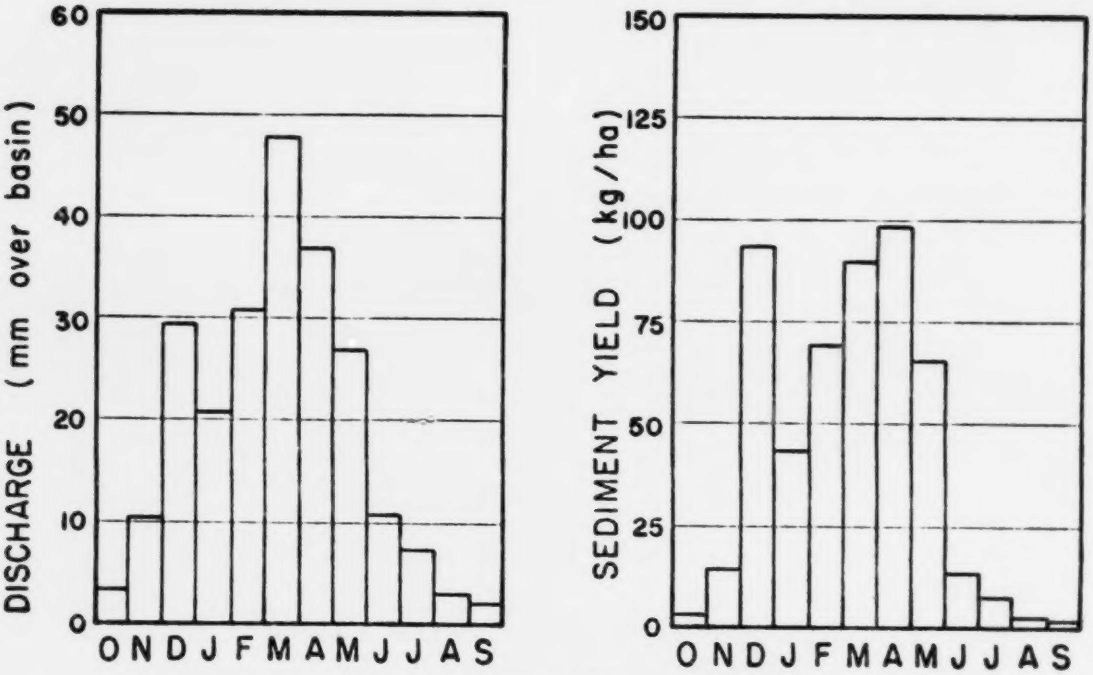


Figure 7.51 Sediment Load and Related Parameters for the Maumee River from June, 1971, to September, 1971



(a) Average monthly discharge (left) and sediment yield (right)

| WATER YEAR | O | N | D | J | F | M | A | M | J | J | A | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | 2 | 4 | 9 | 3 | 30 | 21 | 4 | 15 | 8 | 2 | 1 | 1 |
| 70 | 2 | 12 | 4 | 3 | 14 | 16 | 24 | 15 | 3 | 4 | 2 | 1 |
| 69 | 1 | 3 | 9 | 27 | 15 | 5 | 15 | 11 | 6 | 6 | 1 | 1 |
| 68 | 1 | 3 | 25 | 7 | 17 | 9 | 8 | 13 | 9 | 4 | 3 | 1 |
| 67 | - | 7 | 32 | 4 | 11 | 21 | 11 | 10 | 2 | 1 | 1 | - |
| 66 | 6 | 3 | 15 | 13 | 8 | 12 | 8 | 22 | 3 | 7 | 2 | 1 |
| 65 | - | 1 | 1 | 7 | 16 | 31 | 30 | 8 | 2 | 1 | 1 | 2 |
| 64 | - | 1 | - | 2 | 1 | 28 | 49 | 9 | 7 | 1 | 1 | - |
| 63 | 1 | 1 | 1 | 1 | 2 | 58 | 17 | 4 | 8 | 4 | 2 | 1 |
| 62 | 2 | 5 | 2 | 18 | 14 | 44 | 6 | 4 | 2 | 1 | 1 | 1 |

| WATER YEAR | O | N | D | J | F | M | A | M | J | J | A | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 71 | - | 1 | 4 | 1 | 45 | 21 | 1 | 17 | 8 | 1 | - | - |
| 70 | 1 | 11 | - | - | 8 | 11 | 33 | 31 | 1 | 2 | 1 | - |
| 69 | - | - | 15 | 32 | 16 | 2 | 17 | 9 | 4 | 4 | - | - |
| 68 | - | - | 41 | 6 | 11 | 4 | 10 | 20 | 6 | 1 | - | - |
| 67 | - | 8 | 50 | - | 7 | 16 | 8 | 10 | - | - | - | - |
| 66 | 5 | 1 | 13 | 15 | 9 | 8 | 7 | 30 | - | 11 | - | - |
| 65 | - | - | - | 3 | 35 | 23 | 36 | 2 | - | - | - | - |
| 64 | - | - | - | - | - | 28 | 57 | 2 | 2 | - | - | - |
| 63 | - | - | - | - | - | 85 | 10 | - | 3 | 1 | - | - |
| 62 | - | 1 | - | 30 | 11 | 54 | 1 | 1 | 1 | - | - | - |

(b) Monthly percentage of yearly discharge (left) and sediment yield (right)

**Figure 7.52 Average Monthly Discharge and Sediment Yield for the Maumee River (a) and Monthly Percentage of Yearly Discharge and Sediment Yield (b) for a Ten-Year Period, October, 1961, to October, 1971**

# *Leadership Important to Acceptance of Conservation*

**SECTION 8**
**An Assessment of Attitudes and Agricultural Practices Among Landowners of Black Creek.**

By
Ralph M. Brooks
David L. Taylor

During the past year, the sociological studies section of the Black Creek Project has devoted most of its energies to the analysis of data obtained in the initial interview among landowners. Herein reported are examples of three different sub-projects that contribute to a better understanding of local people and how they perceive their pollution problems. Rather than present them as three separate papers, they appear as one paper with three separate parts.

First, attitudes of both Amish and non-Amish landowners are compared in an attempt to better understand how local people perceive pollution control and their willingness to participate in abatement programs. Comparing Amish and non-Amish attitudes is much like comparing apples and oranges. Both groups need to be understood in their cultural context. This is particularly true for the Amish. Other documents are being prepared to do this and will be made available in the near future.

Second, is an explanation of the leadership structure among the non-Amish landowners. Assumptions are made of the role leaders can play with respect to the diffusion of agricultural technology among the non-leaders. Third, preliminary examination of the types of fertilizers used by both Amish and non-Amish give indication to what landowners are applying to the land. This analysis is considered desirable as an aid to further the understanding of nutrients observed from data gathered in the water runoff studies. There is also an attempt to provide meaningful data on the level of nitrogen applied to the soil for each of the sub-watersheds within the 12,000-acre Black Creek area.

# 1. ATTITUDES TOWARD POLLUTION CONTROL

Part I of this report is an attempt to present attitudinal data obtained in the initial interview. In all, the farmers' responses to 17 separate questions are presented. These questions fall into three main categories: (1) attitudes regarding soil conservation, pollution and pollution control, (2) costs of preventative measures and appropriate action and (3) attitudes toward pollution control programs and specifically the Black Creek Project.

## A. Attitudes Toward Soil Conservation

One of our interests was to assess the extent of agreement between Amish and non-Amish concerning conservation of soil and pollution of the streams. The farmers in the study were asked to agree or disagree with two general statements about pollution and conservation problems in the Black Creek Watershed. First, they were asked, "Conservation of soil is not a real problem in this area." A person agreeing with this statement, would indicate that there is no problem, as far as he is concerned, with conservation of soil in the area. A disagreement with this statement, however, would suggest that there are problems in the area concerning conservation of soil and that in the farmer's opinion, there might be a need for some type of program.

Table 8.1 shows about half of both the Amish and non-Amish believe that conservation of soil is not a real problem in their area. This suggests a relatively high lack of awareness of the extent of the erosion problems in the Black Creek Watershed. Yet, in these farmers' minds, it is not a real problem. It is also notable that a higher percentage of the non-Amish, than of the Amish, believe there is such a problem (49 percent and 31 percent, respectively) with a larger percentage of the Amish remaining undecided on the issue (22 percent). Future analysis will look at the demographic characteristics of the Amish and non-Amish who have agreed

**Table 8.1 Conservation of soil is not a real problem in this area.**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 15 | 46.9 | 26 | 45.6 |
| DK | 7 | 21.9 | 3 | 5.3 |
| Disagree | 10 | 31.2 | 28 | 49.1 |
| Total | 32 | 100.0 | 57 | 100.0 |

that conservation of soil is not a real problem in the area. Perhaps we can learn from a comparison between these two groups on their social characteristics what might be a contributing factor to the attitude that they hold.

The second related statement, concerns the pollution of streams. Farmers were presented a question, "Pollution of streams is a major problem in this county." In table 8.2, we see a greater Amish- non-Amish difference with only 19 percent of the Amish seeing this as a problem and more than half (53 percent) of the non-Amish believing this to be true.

It is interesting to note that approximately 44 percent of the Amish "Do not know" whether or not pollution of streams is a major problem in the county. This attitude could be a result of the isolation and lack of mobility by these people. For example, traveling throughout the area by horse and buggy limits the distances which people are willing to travel. Furthermore, they are not as likely to take a Sunday afternoon drive through the country as some of the non-Amish farmers might do. During our interviewing, we found that many of the Amish farmers had never been to the Maumee River, and some of them had not been to the Black Creek for many months. Therefore, they actually did not know whether or not pollution of the streams was a problem. There is also some evidence that suggests the definition of pollution is difficult for the Amish to handle, as well as the non-Amish.

A third question, somewhat related to the first two, dealt with sewage disposal. Farmers were asked, "In your opinion, how adequate is sewage disposal in this area?" In table 8.3, the responses show that while less than half of both the Amish and non-Amish see their system as inadequate, most do not believe that it is adequate either. About one-third of the non-Amish are satisfied with the present system, but only 13 percent of the Amish are satisfied. Of course this question refers to the watershed area and not just individual household waste. The Amish have pit-toilets compared to inside plumbing for non-Amish. Often we got the response, "Well I know in some places around Harlan it sure smells."

**Table 8.2 Pollution of streams is a major problem in this county.**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 6 | 18.8 | 30 | 52.6 |
| DK | 14 | 43.8 | 11 | 19.3 |
| Disagree | 12 | 37.4 | 16 | 28.1 |
| Total | 27 | 100.0 | 57 | 100.0 |

**Table 8.3 In your opinion, how adequate is sewage disposal in this area (referring to the Basin)?**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Completed Adequate | - | -- | 1 | 1.8 |
| Adequate | 4 | 12.5 | 20 | 35.1 |
| Inadequate | 11 | 34.4 | 25 | 43.9 |
| Completely Inadequate | 3 | 9.4 | 3 | 5.3 |
| DK | 12 | 37.5 | 6 | 10.5 |
| N/R | 2 | 6.3 | 2 | 3.6 |
| Total | 32 | 100.0 | 57 | 100.0 |

Again, the size of the "Do not know" category for the Amish points out an extreme lack of information on their part. At any rate, were the farmers to have greater knowledge of the extent of the local pollution problem, the inadequate categories could be expected to increase proportionately.

When asked about the effectiveness of pollution controls in the area, the Amish feel that they do not have enough information to respond. The non-Amish, on the other hand, are evenly divided between positive and negative evaluations of the present system. We asked farmers "How effective do you think that pollution control is for the Black Creek now?" In table 8.4, however, only 12 percent of the non-Amish rated pollution control as good. Although the majority rated it as fair, nevertheless, even among the non-Amish they apparently believe that there are problems with pollution control in the Black Creek.

With regard to the specific causes of the area's pollution problems, the non-Amish farmers were presented with the following statement, "Which of the following sources do you think contributes most to pollution in the Black Creek? Please rank them 1, 2, and 3." We presented the list of seven sources and asked the farmers to rank them. In table 8.5 are listed the 1st, 2nd and 3rd responses. The Amish were asked open ended questions and their data do not appear in table 8.5. As indicated in table 9.5, 20 percent of the farmers rated sewage as the number one source of pollution in the Black Creek. The second source was a tie between rubbish and trash and silt. In the second ranking of problems, again sewage came up as 18 percent of the total response with rubbish and trash ranking second and kitchen and laundry waste ranking third (10 percent). Not until the third choice did silt (16.9 percent) come up as a major contributor to pollution in the Black Creek. These findings again indicate that many of the farmers are not completely aware of the extent of the erosion problem in the area, especially the contribution that silt can make to pollution in the Black Creek.

**Table 8.4 How effective do you think that pollution control is for the Black Creek now?**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Good | 3 | 9.4 | 7 | 12.3 |
| Fair | 2 | 6.2 | 23 | 40.0 |
| Poor | 10 | 31.3 | 14 | 24.6 |
| Very Poor | 0 | 0.0 | 4 | 7.0 |
| Isn't Any | 0 | 0.0 | 2 | 3.5 |
| DK | 15 | 46.9 | 7 | 12.2 |
| N/R | 2 | 6.2 | 0 | 0.0 |
| Total | 32 | 100.0 | 57 | 100.0 |

## B. Cost of Prevention Measures

The second main area of attitudinal data concerns the cost of pollution control and related activities. In order for much of the work to be accomplished, obviously someone has to pay for it. The question is who should pay and to what extent.

At a very general level, farmers were asked, "Would you agree or disagree that spending money for soil and water development is a good investment?" As demonstrated in table 8.6, the Amish and the non-Amish were overwhelmingly in favor of this idea, demonstrating a favorable sentiment to the development of pollution control procedures. However, the data from this question do not indicate whose money the farmers are interested in spending.

When asked, "The cost of soil erosion reducing practices should be borne entirely by those whose land is effected," as indicated in table 8.7, most farmers are not interested in spending their own money for such procedures. The majority of both Amish and non-Amish feel that both sources should share at least part of the

**Table 8.5 Which of the following sources do you think contributes most to pollution in the Black Creek? Please rank them 1, 2, and 3***

| Source | 1st | | 2nd | | 3rd | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Silt | 11 | 12.4 | 6 | 6.7 | 15 | 16.7 | 32 | 37.1 |
| Farm and animal waste | 1 | 1.1 | 4 | 4.5 | 3 | 3.4 | 8 | 9.0 |
| Kitchen and laundry waste | 6 | 6.7 | 9 | 10.1 | 7 | 7.9 | 22 | 25.9 |
| Farm run-off of fertilizer and pesticides | 1 | 1.1 | 1 | 1.1 | 5 | 5.6 | 7 | 7.9 |
| Rubbish and trash | 11 | 12.4 | 10 | 11.2 | 11 | 12.4 | 32 | 36.0 |
| Sewage | 18 | 20.2 | 16 | 18.0 | 8 | 9.0 | 42 | 47.1 |
| Wastes for commercial and industry | 2 | 2.2 | 4 | 4.5 | 1 | 1.1 | 7 | 9.0 |
| DK | 5 | 5.6 | 5 | 5.6 | 5 | 5.6 | 15 | 13.4 |
| N/R | 2 | 2.2 | 2 | 2.2 | 2 | 2.2 | 6 | 6.7 |
| Total | 57 | 100.0 | 57 | 100.0 | 57 | 100.0 | 57 | 100.0 |

**Table 8.6 Would you agree or disagree that spending money for soil and water development is a good investment?**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 26 | 81.3 | 52 | 91.2 |
| Disagree | 0 | 0.0 | 2 | 3.5 |
| DK | 5 | 15.6 | 2 | 3.5 |
| N/R | 1 | 3.1 | 1 | 1.8 |
| Total | 32 | 100.0 | 57 | 100.0 |

**Table 8.7 The cost of soil erosion practices should be borne entirely by those whose land is affected.**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 7 | 21.9 | 18 | 31.6 |
| DK | 10 | 31.3 | 6 | 10.5 |
| Disagree | 15 | 46.8 | 33 | 57.9 |
| Total | 32 | 100.0 | 57 | 100.0 |

Table 8.8 Who should pay for the efforts in this district to control pollution? Indicate the percentage of payment by each group.*

| Percentage | TYPE OF PAYMENT | | | | | |
|---|---|---|---|---|---|---|
| | Federal | | State | | Local | |
| | N | % | N | % | N | % |
| 0-25 | 9 | 11.2 | 24 | 26.9 | 22 | 24.7 |
| 26-50 | 35 | 39.4 | 21 | 23.6 | 19 | 21.3 |
| 51-75 | 1 | 1.1 | - | -- | 1 | 1.1 |
| 76-100 | - | -- | - | -- | 3 | 3.3 |
| DK | 10 | 11.2 | 10 | 11.2 | 10 | 11.2 |
| N/R | 2 | 2.2 | 2 | 2.2 | 2 | 2.2 |
| Total | 57 | 100.0 | 57 | 100.0 | 57 | 100.0 |

**Table 8.9 If government assistance is given for pollution control, what level of government should be the principle source of assistance for households, farms and businesses or industries?***

| Level of Government | Households | | Farms | | Business & Industry | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Federal | 16 | 18.0 | 22 | 24.7 | 22 | 24.6 |
| State | 7 | 7.9 | 6 | 6.7 | 10 | 11.2 |
| County | 13 | 14.6 | 11 | 12.4 | 4 | 4.5 |
| Town | 1 | 1.1 | - | -- | - | -- |
| City or Village | 3 | 3.4 | - | -- | 2 | 2.2 |
| Unspecified Locale | 7 | 7.9 | 8 | 9.0 | 9 | 10.1 |
| DK | 7 | 7.9 | 6 | 6.7 | 6 | 6.7 |
| N/R | 3 | 3.4 | 4 | 4.5 | 4 | 4.5 |
| Total | 57 | 100.0 | 57 | 100.0 | 57 | 100.0 |

**Table 8.10 Federal Taxation to Clean Up Our Water Wouldn't be Too Expensive to Consider (Amish Were Not Asked This Question)**

| Response | Non-Amish | |
|---|---|---|
| | N | % |
| Strongly Agree | 3 | 5.2 |
| Agree | 20 | 35.1 |
| Neutral | 8 | 14.0 |
| Disagree | 24 | 42.1 |
| Strongly Disagree | 1 | 1.8 |
| No Response | 1 | 1.8 |
| Total | 57 | 100.0 |

**Table 8.11 Even Considering the High Cost of Pollution Control, All Available Pollution Control Techniques Should be Applied (Amish Were Not Asked This Question)**

| Response | Non-Amish | |
|---|---|---|
| | N | % |
| Strongly Agree | 2 | 3.5 |
| Agree | 24 | 42.1 |
| Neutral | 10 | 17.5 |
| Disagree | 20 | 35.1 |
| Strongly Disagree | 0 | 0.0 |
| No Response | 1 | 1.8 |
| Total | 57 | 100.0 |

economic burden for instituting soil erosion reducing practices. There is still a significant group responding "Do not know" to the question. Perhaps these individuals are not aware of the costs of reducing soil erosion and/or what constitutes soil erosion. This attitude is demonstrated more clearly by two additional questions asked only of the non-Amish.

When asked, "Who should pay for the efforts to control pollution," farmers were given three types of payment. They could select federal, state or local government. Of course, the local category would include money from their own pockets. When asked who should pay for pollution control, most farmers thought that the federal government should pay the largest share, with 40 percent of the farmers saying government should contribute one-fourth to one-half of the cost. In addition, less money was expected from state and local sources (less than one-fourth of the cost, see table 8.8).

When respondents were asked, "If government assistance is given for pollution control, what level of government should be the principal source of assistance for household, farms and businesses or industries?," again the federal level of government came out on top. This would suggest a greater involvement of federal government in local affairs. In table 8.9, the federal level of government came out on top at 18 percent for aid to households, 24 percent in aid to farms and 24 percent in aid to business or industry. It is interesting to note that no other level of government approaches these percentages for households, farms or business or industry. In fact, most of the other levels of government are only half of what is expected from the federal level.

Furthermore, when the issue of federal taxation to pay for such programs was raised, the non-Amish were almost evenly divided on the issue with nearly 40 percent in favor and 44 percent opposed to the idea. In table 8.10 federal taxation was raised as an issue to be considered for financing pollution control. This is interesting because in view of tables 8.7 and 8.8, a large proportion of farmers inferred that the federal government should be involved in the financing of pollution control. This suggests that farmers almost want their cake and eat it too. If federal government is to be more involved in financing of pollution control practices, the only way money can come is probably through taxation.

However, even though some of the farmers may not be in favor of the more immediate solutions, the desire to control pollution (even at high cost) is still evident as demonstrated in table 8.11. Here respondents were asked to agree or disagree with the statement concerning the application of all available pollution control techniques even in spite of high costs. Approximately 45 percent of the non-Amish farmers either agreed or strongly agreed with applying pollution control techniques, whereas 35 percent disagreed.

Although the farmers appeared to be generally in favor of the idea of pollution control, nevertheless, they sometimes balk at the immediate sounding solutions which have been proposed. Obviously a great educational effort on the part of those involved in the project will be necessary to overcome some of these objections.

## C. Pollution Control Programs and the Black Creek Project

Many of the tables discussed thus far, refer to pollution control in general. Not all of them refer to the Black Creek Project. Therefore, a number of different questions were presented to both the Amish and non-Amish farmers giving them an opportunity to express their opinions about the Black Creek Project. These start with table 8.12 where the question, "The average landowner stands to lose more than he would gain by soil and water development programs" was asked. Both the Amish and the non-Amish demonstrated support by disagreeing with this statement. Fifty-three percent of the Amish and 65 percent of the non-Amish disagreed which indicates they personally felt they would gain more than they would lose by soil and water development programs.

More specifically, in table 8.13, we asked whether or not non-Amish farmers would benefit from the demonstration project. Seventy-five percent of them agreed, indicating they felt it would be of benefit to residents in the area.

Of particular concern to project personnel was whether or not local farmers would feel too much pressure had been placed upon them to participate in this conservation project. Therefore, as table 8.14 indicates, they were asked, "Would you agree or disagree that the watershed program is being pushed too hard." Very few of the Amish and the non-Amish farmers agreed with the statement. A majority, in both cases, indicated that the program was not being pushed too hard in their opinion. It might also be pointed out that when these interviews took place, it was at the early development of the project in the area. Therefore, most of the local farmers did not have an opportunity to come in direct contact with project personnel, although some had. In a year or two, it should be interesting to find what kind of changes exist in Amish and non-Amish attitudes concerning the manner in which the watershed program was presented.

Not all of the questions presented in this section of the report were given to both Amish and non-Amish. In some instances, the question was inappropriate for the Amish interview. An example of this is in table 8.15. To see if the farmers legitimized the authority and respect of the decisions of project personnel the non-Amish farmers were asked if they felt project decisions should be made by professionals. The results show that 68 percent of the farmers agreed to having professionals involved in making major decisions regarding the demonstration project. This would also appear to indicate the farmers' respect for these decisions and respect for the people involved. The Amish, on the other hand, probably are unaware of the kinds of professionals and the technical training they may have in dealing with water and soil management.

As a final check on the local farmers' attitudes toward government involvement in conservation programs, we asked the question reported in table 8.16. Again, we were interested in knowing to what extent the federal government should play a role in soil conservation programs in this county. Nearly two-thirds of both groups gave a positive response to this statement. Finally, local farmers were asked "Which do you think is a better way to get people to cooperate in helping to protect the water quality in the Black Creek; by education, financial incentives or by laws and controls?" In table 8.17, both the Amish and the non-Amish selected educational methods as perhaps the best way to get people involved in protecting water quality in the Black Creek. Oftentimes, the Amish would respond in this manner: "If you have laws and control, that indicates stronger government intervention. If you have financial incentives, that's getting something for nothing. So, the best way would be through education because that would be enduring over time."

It must be said that these attributes are preliminary attitudes that Amish and non-Amish held prior to extensive involvement in watershed activities by project personnel. Although there had been some periods where it was doubtful whether or not some of the Amish would participate in the project, we believe that the amount of success thus far has been extremely favorable. In spite of the cultural differences found in the Amish community, plus the added language barrier, project personnel have been able to involve many Amish in various individual, as well as joint, farm efforts.

**Table 8.12 The Average Land Owner Stands to Lose More Than He Will Gain by Soil and Water Development Programs**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 1 | 3.1 | 7 | 12.3 |
| DK | 14 | 43.8 | 13 | 22.8 |
| Disagree | 17 | 53.1 | 37 | 64.9 |
| Total | 32 | 100.0 | 57 | 100.0 |

**Table 8.13 Almost Everyone in the Area Will Be Benefitted From This Demonstration Project (Amish Were Not Asked This Question)**

| Response | Non-Amish | |
|---|---|---|
| | N | % |
| Agree | 43 | 75.4 |
| DK | 2 | 3.5 |
| Disagree | 12 | 21.1 |
| Total | 47 | 100.0 |

**Table 8.14 Would You Agree or Disagree That the Watershed Program is Being Pushed too Hard**

| Response | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 3 | 9.4 | 6 | 10.5 |
| DK | 10 | 31.3 | 6 | 10.5 |
| Disagree | 18 | 56.2 | 44 | 77.2 |
| No Response | 1 | 3.1 | 1 | 1.8 |
| Total | 32 | 100.0 | 57 | 100.0 |

**Table 8.15 Most of the Major Decisions in the Demonstration Project Should be Made by People with Professional and Technical Training in Water and Soil Management (Amish were not asked this question)**

| Response | Non-Amish | |
|---|---|---|
| | N | % |
| Agree | 39 | 68.4 |
| DK | 6 | 10.5 |
| Disagree | 12 | 21.1 |
| Total | 57 | 100.0 |

**Table 8.16 The Federal Government should play an important role in soil conservation programs in this county.**

| Response | Amish |  | Non-Amish |  |
|---|---|---|---|---|
|  | N | % | N | % |
| Agree | 20 | 62.5 | 36 | 63.2 |
| DK | 10 | 31.3 | 6 | 10.5 |
| Disagree | 2 | 6.2 | 15 | 26.3 |
| Total | 32 | 100.0 | 57 | 100.0 |

**Table 8.17 Which Do You Think is a Better Way to Get People to Cooperate in Helping to Protect Water Quality in the Black Creek: by Education, Financial Incentives, or by Laws and Controls**

| Response | Amish |  | Non-Amish |  |
|---|---|---|---|---|
|  | N | % | N | % |
| Education | 13 | 40.6 | 35 | 61.5 |
| Financial Incentive | 4 | 12.5 | 8 | 14.0 |
| Laws and Controls | 1 | 3.1 | 8 | 14.0 |
| Other | 2 | 6.3 | 2 | 3.5 |
| DK | 11 | 34.4 | 2 | 3.5 |
| N/R | 1 | 3.1 | 2 | 3.5 |
| Total | 32 | 100.0 | 57 | 100.0 |

## 2. Attitudes Toward Pollution Control Among Leaders and Non-Leaders

In much of the sociological literature on adoption and diffusion of agricultural technology, there is evidence suggesting that opinion leaders play a key role in how rapidly information is disseminated. Therefore, locating the perceived leaders in the watershed can be instrumental to the overall success of the project. The introduction of agricultural technology to key opinion leaders throughout the watershed demonstrates the utilization of already existing social patterns. The impact of this approach is expected to continue beyond the duration of the project.

The identification of opinion leaders among landowners in the agricultural community was made possible through information obtained from the questionnaire. First, farmers were asked to name a local farmer whom they believed was generally "well respected for his agricultural practices." Second, they were asked to indicate whether or not they had ever gone to that person for agricultural advice. In this manner, we were not only able to ascertain the farmers' beliefs regarding "knowledgeables" in the area, but in addition, to somehow measure their behavior as a product of their beliefs. The responses to these two questions are presented in figure 8.1, and represent the non-Amish community within the watershed.*

The lines in figure 8.1 are meaningful. A thin line indicates the respondents' choice of an opinion leader, but that the respondent did not go to him for advice. A thicker arrow indicates that not only did the respondent believe this person to be well respected, but also that he had gone to this landowner for advice. It should be noted that in the sociogram, the size of the circles have been adjusted to be indicative of which farmers were chosen by the most respondents, with the largest circles being those persons chosen most often.

The two questions on which this figure is based, serve two different functions in assessing the social relationships within the community. The first question, "Discovering which farmers are well respected" is a measurement of the social structure of the community. Furthermore, it enables one to identify those persons who hold the most influential and important positions in the community. The second question allows the assessment of the closeness of the relationship between the respondent and the person he chose. In summary, while the thickness of the arrows indicate the interpersonal relationships, the position of the arrows indicate the social structure of the non-Amish farm community.

This information is important to the project because eight key farmers had been identified to aid in the progress of the project. New ideas, as well as the introduction of conservation practices, can be presented to them in an effort to speed up the process of participation in watershed activities. It is important to recognize the existance of a social structure and operate within it. Although the Amish did not respond to these questions of leader identification, nevertheless, they have a social

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*These same questions were also presented to approximately one-fourth of the Amish landowners. Their response, however, was different than the non Amish. Non Amish responded readily to the questions. The Amish, however, hesitated and even with intensive probing, would not provide a response. One of their beliefs is that pride should be avoided. Hence, asking an Amishman to select another as a "knowledgeable farmer" would tend to elevate one over the other. Besides, their livelihood is agricultural and "we are all supposed to be good farmers." Therefore, the Amish did not respond to the questions, although there is evidence suggesting advice is sought from parents and other relatives concerning agricultural operations on the farm.

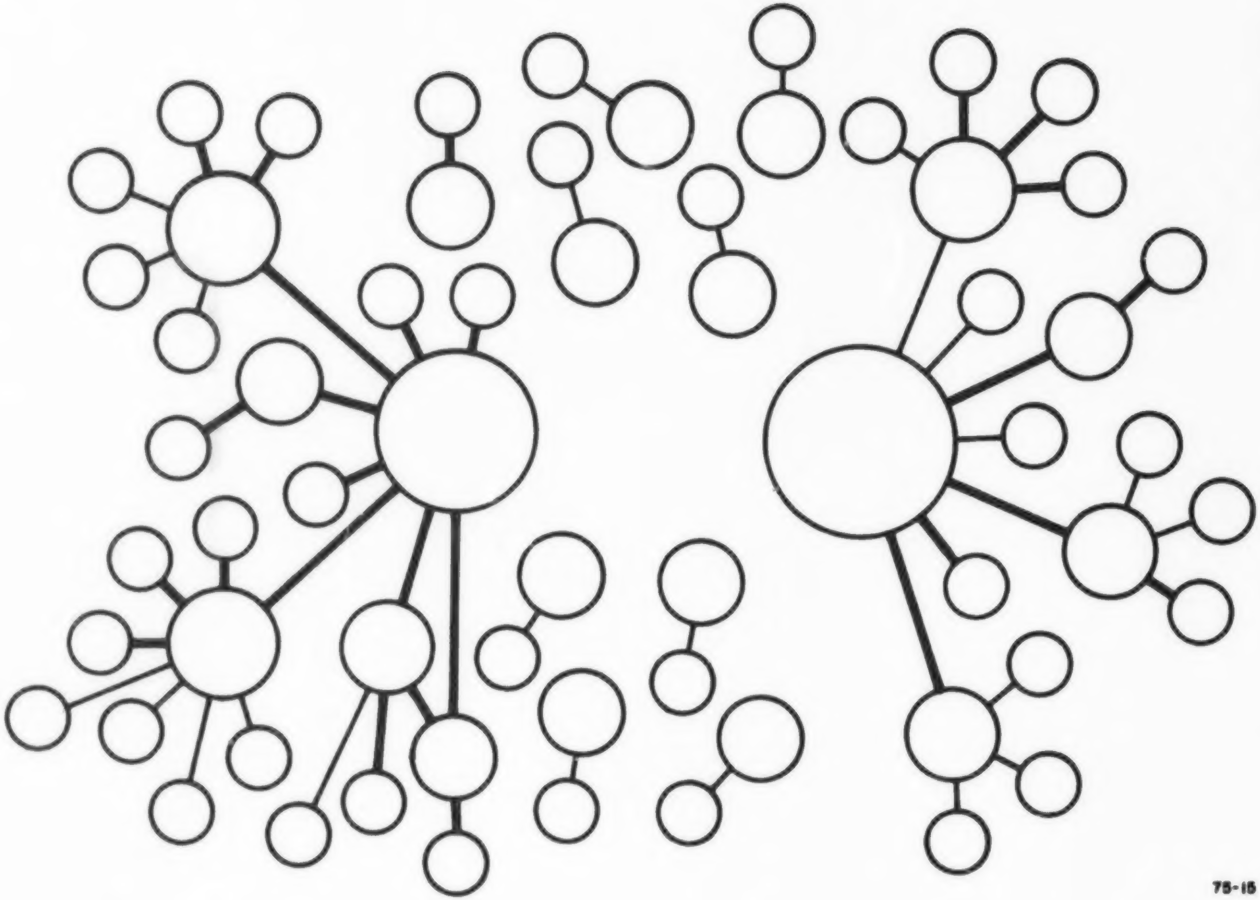


Figure 8.1 Sociometric choice patterns of farmers: An illustration of opinion leadership among the non-Amish in the Black Creek.

structure in their community that must be recognized if any degree of success is to be expected. The Bishop is a key figure in the Amish church district. Without his approval, little can be accomplished. With his approval, meetings can be scheduled and cooperation anticipated. It is important to know and understand these two systems and how they affect working relationships among landowners.

To serve as a cross-check on the validity of the data displayed in the sociogram, farmers were asked to select people to serve on a pollution control board. Each respondent provided the names of three people he would like to see serve on such a board, if one were developed in their area. These board members would hold positions of importance in the area exerting influence within the community relative to decisions on pollution control. Furthermore, they would have contact with government as representatives of the area farmers. We assume that when farmers gave their three choices, they were looking for people they could trust, whose judgement they could respect and in whom they were willing to feel confident.

A comparison was made between the group of eight farmers selected as opinion leaders and the group generated in the question concerning the pollution control board. Of the eight farmers selected in either the "Opinion" or the "Advise" questions, six were also most often selected as members of the pollution control board. This further confirms our beliefs that the farmers selected as leaders in figure 8.1 are, in fact, considered to be respected and influential in the community.

## A. Comparison of Leaders and Non-Leaders

It was expected, based on findings from previous studies, that the persons chosen as leaders would differ from those not chosen (the non-leaders). They would be more conscious of pollution, more interested in doing something about it and hence, more favorable to the Black Creek Project and pollution control techniques. To test this assumption, a number of comparisons were made between the leaders and the non-leaders in four areas: (1) the farmers' perception of pollution as a problem, (2) the farmers' use of pollution control practices on their land, (3) the role that farmers feel government should play in pollution control and (4) the farmer's attitudes toward the Black Creek Project. The balance of Part 2 will examine each of these four areas in turn.

## B. Perceiving Pollution as a Problem

The farmers were asked to agree or disagree with the statement that "The conservation of soil is not a real problem in the Black Creek area." As can be seen in table 8.18, both the leaders and the non-leaders tended to be evenly split on this issue. Since one of the first tasks of the Black Creek Project has been to make the landowners aware that a problem exists, these results indicate that there is still much work to be done when it comes to demonstrating to the farmers that a pollution problem does exist in their area. As of the present, we have not traced out the relationships between the four leaders who agree and which of the nonleaders they influence. Likewise, we have not done the same thing for those who disagree and their patterns of influence. This is under consideration for a near future report.

To discover which sources contribute most to the pollution of the Black Creek, respondents were given a list of seven common pollutants and asked to indicate three which they felt were major contributors to pollution in their area. Table 8.19 shows

**Table 8.18 Conservation of Soil is not a Real Problem in This Area**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 4 | 50.0 | 22 | 44.9 |
| Disagree | 4 | 50.0 | 24 | 49.0 |
| DK | 0 | 0.0 | 3 | 6.1 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.19 Which Three of the Following Sources Do You Think Contributes Most to Pollution in the Black Creek**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Silt | 6 | 75.0 | 27 | 55.1 |
| Farm and other animal wastes | 0 | 0.0 | 6 | 12.2 |
| Kitchen and laundry waste water | 2 | 25.0 | 7 | 14.3 |
| Farm runoff of fertilizer and pesticides | 0 | 0.0 | 1 | 2.0 |
| Rubbish and trash | 0 | 0.0 | 2 | 4.1 |
| Sewage | 0 | 0.0 | 4 | 8.2 |
| Wastes from commercial and industry | 0 | 0.0 | 2 | 4.1 |
| Total | 8 | 100.0 | 49 | 100.0 |

that the single source most often picked was "Silt." Among 75 percent of the leaders and a major portion of the non-leaders, silt was identified as a prime polluter. It is interesting to note that in table 8.5, the selection of silt as a prime polluter was not considered by the majority of the farmers in the watershed. As you recall, it was the third choice by most of the farmers. However, among the leaders, as demonstrated in table 8.19 silt came out on top. In addition, other sources receiving more than 10 percent of the non-leaders choices were "kitchen and laundry wastewater" and "farms and other animal wastes."

For the second part of the question, respondents were asked which of the sources of pollution that they named, was the single most important contributor to pollution in the area. In table 8.20, a variation of response can be identified. For instance, among the leaders, half of them selected silt as the primary cause. The next was sewage. Among the non-leaders, however, only 14 percent selected silt as the primary cause with a greater percentage selecting sewage (33 percent) and rubbish

**Table 8.20 Please Rank These Three Sources as the First, Second, and Third Most Important Causes (This Table Only Presents Responses for the Source Ranked First Most Important)**

| Response | Leader |  | Non-Leader |  |
|---|---|---|---|---|
|  | N | % | N | % |
| Silt | 4 | 50.0 | 7 | 14.3 |
| Farm and other animal wastes | 0 | 0.0 | 1 | 2.0 |
| Kitchen and laundry waste water | 1 | 12.5 | 5 | 10.2 |
| Farm runoff of fertilizer and pesticides | 0 | 0.0 | 1 | 2.0 |
| Rubbish and trash | 1 | 12.5 | 10 | 20.4 |
| Sewage | 2 | 25.0 | 16 | 32.7 |
| Wastes from commercial and industry | 0 | 0.0 | 5 | 10.2 |
| N/R | 0 | 0.0 | 4 | 8.2 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.21 Do You Have a Conservation Plan with the Soil and Water Conservation District Office**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 5 | 62.5 | 10 | 20.4 |
| No | 3 | 37.5 | 38 | 77.6 |
| N/R | 0 | 0.0 | 1 | 2.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.22 Are You Interested in Developing Such a Plan (Table only Refers to Those Who Don't Yet have a Plan)**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 2 | 66.7 | 13 | 33.3 |
| No | 1 | 33.3 | 20 | 51.3 |
| N/R | 0 | 0.0 | 6 | 15.4 |
| Total | 3 | 100.0 | 39 | 100.0 |

**Table 8.23 Even Considering the Costs, All Available Pollution Control Techniques Should be Applied**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Strongly Agree | 0 | 0.0 | 2 | 4.1 |
| Agree | 4 | 50.0 | 20 | 40.8 |
| Neutral | 2 | 25.0 | 8 | 16.3 |
| Disagree | 2 | 25.0 | 18 | 36.7 |
| DK | 0 | 0.0 | 1 | 2.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.24 Trees are of Little Value in Keeping the Soil from Washing Away**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 1 | 12.5 | 8 | 16.3 |
| Disagree | 6 | 75.0 | 39 | 79.6 |
| DK | 1 | 12.5 | 2 | 4.1 |
| Total | 8 | 100.0 | 49 | 100.0 |

and trash (20 percent). This would indicate that leaders tend to have a more active perception of the pollution problems in the Black Creek area than do the non-leaders. If the patterns of influence and leadership are allowed to operate in the area, we would expect to see some change in the perception of the non-leaders ranking of causes of pollution in the near future.

An important measure of the farmers interest in pollution control and conservation is whether or not the farmer has developed a conservation plan for his land. Table 8.21 indicates the percentage of leaders and non-leaders who have conservation plans for their farms. It can be seen that a much higher percentage of the leaders have already developed such a plan than the non-leaders (62.5 percent and 20.4 percent, respectively).

Although a leader and non-leader may indicate they presently do not have a conservation plan, nevertheless, they may also have some interest in developing a plan in the future. In table 8.22, those who responded "No" in table 8.21 are presented to see what percent of those who do not have a plan would be interested in establishing one. There is a significant increase in the percent indicating that they would be interested in developing a plan. In summary, of the leaders, seven out of eight either have a plan or have interest in developing a plan. Among the non-leaders, on the other hand, 23 of 49 either have a plan or have interest in developing a plan.

Overall, these comparisons show that those persons picked as leaders tend to be more aware of pollution in their area, are more aware of its source and demonstrate greater interest in doing something about it. It will be interesting to see if this same philosophy emerges in some of the non-leaders over the next two years.

## C. Use of Pollution Control Practices

In order to assess the farmers' attitudes toward, and usage of, various pollution control/conservation practices, a number of questions were presented to them which asked for either an opinion or simply called for a statement of fact. The first question the farmers were asked was whether they believed that "In spite of the possibly higher costs, all pollution control techniques should be applied." Although 50 percent of the farmers responded positively to this statement, the other 50 percent were evenly split between disagreeing and undecided. As table 8.23 shows, among non-leaders, the amount of agreement and disagreement was just about equal, somewhere about 40 percent.

This generally favorable attitude was also exhibited with regard to specific pollution control practices. For example, in table 8.24, farmers were asked whether they agreed or disagreed with this statement, "Trees are of little value in keeping the soil from washing away." Even though this statement is negatively worded, a favorable response was still obtained from a great majority of both leaders and non-leaders.

Another part of the questionnaire assessed whether or not the farmers were using 16 specific agricultural and soil conservation practices on their land. Overall, the results showed little differences between the leaders and non-leaders for most of the practices, although there were great differences in the percentages of farmers who used the different practices. The range of variation was quite large — from 2 percent who used contour farming to about 95 percent who utilized tile drains. In general, the percentage of farmers (both leaders and non-leaders) using the conservation practices was rather low. A typical example of this would be the responses to the inquiry about grassed waterways or outlets presented in table 8.25. That only about one-fourth to one-third of the respondents were currently using the practice was typical of the general trend. In most cases, the majority of the respondents felt that some of the practices were not applicable to their land. This would seem to indicate a need for further analysis of the soil types relative to specific farms to see which practices are most appropriate for the individual farmer's land. Such analysis is currently under consideration.

## D. The Role of Government in Pollution Control

It is difficult to ascertain exactly what role local people and the federal government should play in pollution control. When presented with a statement attempting to assess the role government should play in soil conservation programs, a majority of the leaders and the non-leaders (63 percent in table 8.26) agreed that government should play an important role in such programs in the county. Although the positive response to this question indicates that farmers believe government should play an important role in such programs in the county. Although the positive response to this question indicates that farmers believe government should be involved, nevertheless, it does not indicate the capacity of that role the government should play. Even though farmers feel the government should play an important role, it does not necessarily mean they feel the government should exercise control over standards and practices. Indeed, when the farmers were asked their opinion of public regulation of land use practices, the percentage favoring such an idea, as presented in table 8.27, is noticeably lower for the non-leaders but higher for the leaders. This may indicate that the farmers tend to make the distinction between "involvement" and "regulation" and that non-leaders are much more willing to accept the former than the latter.

Another area of interest to both farmers and project personnel is the question of who is going to pay for the proposed conservation programs. Therefore, farmers were asked whether they believed that the farmer whose land was affected should stand the entire cost of the improvements. As demonstrated in table 8.28, the majority of both leaders and non-leaders were definitely against this idea. Hence, what landowners are saying is they feel the government should play an important role in soil conservation in the area and there are some mixed feelings about public regulation of land use practices in the area.

Since both leaders and non-leaders were of the opinion that government should be involved in conservation programs, and that the local farmers should not stand the entire cost, therefore, the question of federal taxation to pay for these improvements was presented to the respondents in two separate questions. The farmers' general attitude toward taxation was assessed through the statement, "Federal taxation to clean up our water completely would not be too expensive to consider." As demonstrated in table 8.29, the response of the leaders demonstrated a wide range of opinion. Among the non-leaders, the response was about equal with 40 percent agreeing and 45 percent disagreeing with the statement. It is uncertain what kind of influence we can expect the leaders to provide for non-leaders given their range of variability on this question. Therefore, with respect to financing of soil and water conservation projects, we will have to resort to educational programs

**Table 8.25 Are You Currently Using Grassed Waterways or Outlets**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 3 | 37.5 | 13 | 26.5 |
| No, but have used it | 0 | 0.0 | 1 | 2.0 |
| Never used it | 1 | 12.5 | 10 | 20.4 |
| Doesn't apply to my land | 4 | 50.0 | 23 | 46.9 |
| N/R | 0 | 0.0 | 2 | 4.1 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.26 The Federal Government Should Play an Important Role in Soil Conservation Programs in This Country**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 5 | 62.5 | 31 | 63.3 |
| Disagree | 2 | 25.0 | 13 | 26.5 |
| DK | 1 | 12.5 | 5 | 10.2 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.27 In Your Opinion Should There be Public Regulation of Land Use Practices or Should This be Left to Individuals to Control**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 7 | 87.5 | 12 | 44.9 |
| No | 1 | 12.5 | 26 | 53.1 |
| DK | 0 | 0.0 | 1 | 2.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.28 The Cost of Soil Erosion Reducing Practices Should be Borne Entirely by Those Whose Land is Affected**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 1 | 12.5 | 17 | 34.7 |
| Disagree | 7 | 87.5 | 26 | 53.1 |
| DK | 0 | 0.0 | 6 | 12.2 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.29 Federal Taxation to Clean Up Our Water Completely Wouldn't be too Expensive to Consider**

| Response | Leaders | | Non-Leaders | |
|---|---|---|---|---|
| | N | % | N | % |
| Strongly Agree | 1 | 12.5 | 2 | 4.1 |
| Agree | 2 | 25.0 | 18 | 36.7 |
| Neutral | 2 | 25.0 | 6 | 12.2 |
| Disagree | 2 | 25.0 | 22 | 44.9 |
| Strongly Disagree | 1 | 12.5 | 0 | 0.0 |
| DK | 0 | 0.0 | 1 | 2.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

**Table 8.30 Do you Agree That There Should be a Special Environmental Improvement Tax Added to Everyone's Income Tax Which would be Used to Pay for Pollution Control Programs**

| Response | Leaders | | Non-Leaders | |
|---|---|---|---|---|
| | N | % | N | % |
| Strongly Agree | 2 | 25.0 | 1 | 2.0 |
| Agree | 1 | 12.5 | 11 | 22.4 |
| Neutral | 2 | 25.0 | 3 | 6.1 |
| Disagree | 2 | 25.0 | 27 | 55.1 |
| Strongly Disagree | 1 | 12.5 | 6 | 12.2 |
| DK | 0 | 0.0 | 1 | 2.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

among the leaders in the area if we expect to use their influence at all.

In addition to assessing general reactions to the idea of federal taxation, the farmers were also asked what they thought about a specific "environmental improvement tax" that would be added to their regular federal taxes. Overall, the reaction of this idea was more negative than the concept of federal taxation. As is shown in table 8.30, this was true especially among the non-leaders where 67 percent opposed the idea. Among the leaders, however, we find a similar pattern with as large a percent agreeing with the statement as disagreeing. In general, the reaction of the farmers to governmental intervention and regulation was fairly positive with leaders being less opposed to regulations than the non-leaders.

## E. Attitudes Toward the Black Creek Project

A major area of leader and non-leader differences discovered was with regard to the Black Creek Project itself. One of the most noticeable areas of difference was simply the familiarity of the farmers with the project. In table 8.31, the eight community leaders were much more familiar with the project than the non-leaders (88 percent and 57 percent, respectively). This would suggest that leaders tend to have more awareness of and/or contact with agencies involved in pollution abatement than do non-leaders. A favorable note here, is that less than six months into the project, the majority of leaders and non-leaders knew something about the Black Creek Project although work had only been initiated in one of two areas of the watershed.

In addition to greater familiarity with the project, the leaders also had a great amount of participation in the planning and implementing of the project in the first phase. As table 8.32 demonstrates, seven of the eight leaders participated, whereas 15 (or 31 percent) of the non-leaders did so. This indicates that most of the leaders have already been approached at one time or another by project personnel. However, since at the time of these contacts the amount of influence these people have within the community was probably not known, it is likely that no special information or consideration was given them. If this were done, it might help the project in reaching some non-leader farmers who would otherwise be hesitant to work with government agencies without being assured by one of their fellow farmers that the project is a worthwhile effort.

The last area of major importance to the Black Creek Project is that of the farmers' attitudes toward and assessment of the project itself. As table 8.33 indicates, the majority of both the leaders and the non-leaders feel that they have an opportunity to express their opinions in planning watershed programs. Although the percentage of the leaders that felt this way was 100 percent nearly twice as high as that for the non-leaders (53 percent).

This may suggest that leaders find the channels of communication through project personnel more open to them than do the non-leaders. It also might suggest that there is an opportunity of coming in contact with project personnel outside of normal Black Creek Project meetings. This points again to the greater contact or possibly the greater interest in pollution control among the leaders.

The overall attitude of the farmers toward the project can be considered thus far to be a positive attitude. This is more clearly demonstrated by the responses in table 8.34. Even considering the negative phrasing of the question, 88 percent of the

Table 8.31 **Are You Familiar with the Black Creek Demonstration Project in This Country**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 7 | 87.5 | 28 | 57.1 |
| No | 1 | 12.5 | 21 | 42.9 |
| Total | 8 | 100.0 | 49 | 100.0 |

Table 8.32 **Have You Participated in any Way in Planning or Implementing the Black Creek Project**

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Yes | 7 | 87.5 | 15 | 30.6 |
| No | 0 | 0.0 | 14 | 28.6 |
| N/R | 1 | 12.5 | 20 | 40.0 |
| Total | 8 | 100.0 | 49 | 100.0 |

Table 8.33 Landowners Have Little Opportunity to Express Their Opinions in Planning Watershed Projects

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 0 | 0.0 | 13 | 26.5 |
| Disagree | 8 | 100.0 | 26 | 53.1 |
| DK | 0 | 0.0 | 10 | 20.4 |
| Total | 8 | 100.0 | 49 | 100.0 |

Table 8.34 The Average Landowners in This Country Stand to Lose More Than He Will Gain by Soil and Water Development Programs

| Response | Leader | | Non-Leader | |
|---|---|---|---|---|
| | N | % | N | % |
| Agree | 0 | 0.0 | 7 | 14.3 |
| Disagree | 7 | 87.5 | 30 | 61.2 |
| DK | 1 | 12.5 | 12 | 24.5 |
| Total | 8 | 100.0 | 49 | 100.0 |

leaders and 61 percent of the non-leaders gave a favorable reaction to the project and how local landowners can benefit by soil and water development programs. This is encouraging because it is difficult at times to measure the benefits in the short run that farmars can receive from some of the conservation practices that have been introduced.

## F. Conclusions

In the short run, project personnel will continue to work throughout the watershed according to a previous schedule developed on the basis of which areas are in greatest need of conservation practices. This will be enhanced by releasing the names of the individuals identified in the sociogram (see figure 8.1) as key leaders in the watershed to project personnel. Hopefully, as we continue to contact landowners with respect to conservation plans and practices, we can do so within the existing social structure. Therefore, in the long run we can anticipate support for project activities from key farmers through the already existing social patterns.

# 3. COMPARISON OF FERTILIZER APPLICATIONS BY AMISH AND NON-AMISH

Although various water runoff studies and stream sampling are scheduled to take place throughout the duration of the project, we felt it would be desirable to have some kind of benchmark data base concerning what kind of fertilizer and how much was applied to the land. Data obtained from landowners through the personal interview allowed us to ascertain the analysis and pounds per acre for crops. The analysis provides a better understanding of the conditions across the watershed and also by sub-watershed. Furthermore, the project personnel are now able to pinpoint excessive applications of fertilizer contributing to high values obtained in water quality studies. In addition, the data can be used jointly with crop yield data to help farmers realize crop potentials resulting from a better understanding of the relationship between soil types, fertilizer applications and crop capabilities.

In this final part of the paper, we present several tables on the type of fertilizer applied to crops by farmers. The comparison between Amish and non-Amish is not meant to be critical, rather, to point to differences in application and crop yields across the watershed. Additional tables demonstrate the amount of nitrogen that is applied to land and how this is concentrated across the six subwatersheds. Finally, an integration of the three parts appears in a final comment section serving as a summary.

## A. Fertilizer Applications by Crops

Tables 8.35 through 8.39 list the fertilizer types applied to each of the crops (corn, wheat, oats, soybeans and hay). The Amish, as might be expected, are heavy users of animal manure as part of their fertilizer program. This usually consists of manure mixed with straw and/or sawdust. The mixture comes from stables as well as milking parlors and confined feedlot operations. Although the Amish tend to

**Table 8.35 Fertilizer Types Applied to Corn**

| Type | Amish | Non-Amish |
|---|---|---|
| 5-20-20 | 2 | - |
| 6-24-24 | - | 3 |
| 8-32-16 | 4 | 4 |
| 10-10-10 | 1 | - |
| 12-12-12 | 17 | - |
| 14-14-14 | - | 1 |
| 15-15-15 | 2 | - |
| 16-16-16 | - | 2 |
| 17-17-17 | - | 1 |
| Cornbuster | - | 1 |
| Manure (5-5-10) | 2 | - |
| Total | 28 | 12 |

spread it as soon as possible, it may sit for a week or two, depending on field conditions. Due to potential leaching problems, as well as variations in the content, the analysis ascribed to manure on Amish farms is 5-5-10. Manure generated and spread on non-Amish farms, however, has been assigned the analysis of 10-5-10 because of the different storage facilities.

An interesting observation is that in general, seldom do Amish and non-Amish use the same fertilizers on each crop. In table 8.35, only one type (8-32-16) was used by both Amish and non-Amish on corn. All other fertilizer types were used by separate groups. About half of the Amish relied on 12-12-12. In table 8.36, the Amish applied only three types to their wheat crop, these were 8-32-16, 12-12-12, and 15-15-15. The non-Amish used none of these mixtures yet ranged from the lowest to the highest in nitrogen application. From the oat crop, it is demonstrated in table 8.37, that there was some commonality between the two groups with 12-12-12 and 15-15-15. However, the Amish again relied most heavily on this mixture, whereas the non-Amish used a variety of fertilizers. Table 8.38 is interesting because it demonstrates the wide range of fertilizer being applied to soybeans — 6-24-24 being the most common. The Amish do not grow soybeans due to harvesting difficulties for

**Table 8.36 Fertilizer Types Applied to Wheat**

| Type | Amish | Non-Amish |
|---|---|---|
| 6-12-12 | - | 1 |
| 6-20-28 | - | 1 |
| 6-24-24 | - | 2 |
| 6-26-26 | - | 1 |
| 8-32-16 | 3 | - |
| 12-12-12 | 6 | - |
| 14-14-14 | - | 2 |
| 15-15-15 | 2 | - |
| 16-16-16 | - | 2 |
| Total | 11 | 9 |

horse drawn equipment. Therefore, their column contains blanks. Finally, in table 8.39, we note that only 10 Amish report of applying some form of fertilizer to hay land.

With respect to the findings in tables 8.35-8.39, the real question is why the difference? The interviews took place in the winter of 1973-74 at the beginning of the fertilizer shortage. Therefore, the difference at that time could not be attributed to supply. The Amish are concentrated more on the upper parts of the watershed and therefore, are also located on different soil types than the non-Amish. Hence, part of the difference may be explained by soil analysis and the needs of the soil for the planned crop. From what we can ascertain, both Amish and non-Amish are supplied by the same dealers in the area. The Amish, however, may rely more on what has worked for them in the past, particularly this is true for their reliance on 12-12-12 and ready-mixes. Yet, most of the fertilizers used by the non-Amish are also premixed. However, the non-Amish do not follow crop rotations as closely as the Amish which could explain their greater variability on types. The Amish, on the other hand, may feel that because of their continuous crop rotations, which in their opinion helps the soil, plus their constant usage of manure, only requires them to supplement their crops with a middle range analysis of chemical fertilizer.

Since our interview, fertilizer availability has seriously declined. In fact, during our interviews, most of the Amish farmers reported they could only buy 10-10-10 and probably could not get the amount that they needed. The "supply question"

**Table 8.37 Fertilizer Types Applied to Oats**

| Type | Amish | Non-Amish |
|---|---|---|
| 6-24-24 | - | 3 |
| 8-32-16 | 3 | - |
| 10-5-5 | - | 1 |
| 10-10-10 | 1 | - |
| 12-12-12 | 18 | 3 |
| 14-14-14 | - | 2 |
| 15-15-15 | 4 | 1 |
| 16-16-16 | - | 8 |
| 19-19-19 | - | 2 |
| Total | 26 | 20 |

probably resulted in the convergence of Amish and non-Amish using the same fertilizer during this 1974-75 growing season with a lower analysis. Therefore, applying fertilizers in the future within the watershed may be a question of "What can I get?" rather than "What do I want and need?" The water quality studies may experience erratic volumes of chemicals depending on the farmer's decision to apply what he can get, whether that is high or low in nitrogen concentration.

## B. Application of Nitrogen by Crops in Sub-watershed

Tables 8.40 and 8.41 contain data on rates of fertilizer application across the watershed by crops and by Amish- non-Amish landowners. Crop yields are also included. The Amish farmers that are shown in table 8.40 on the average, are applying 47.97 pounds of nitrogen per acre on their corn for grain. This resulted in an average yield of 66 bushels per acre. The non-Amish, on the other hand, applied 114.69 pounds of nitrogen per acre on their corn for grain resulting in a yield of 74 bushels per acre (see table 8.41). In reviewing the yield per acre for both Amish and non-Amish farmers, we find that although many of the non-Amish farmers experienced high yields in the 125 bushel range; nevertheless, there were several reporting yields in the range of 20-25 bushels per acre. Among the Amish, we found many of the corn yields in the 70-75 bushel/acre range. However, those reporting lower yields were proportionately fewer for the Amish.

## Table 8.38 Fertilizer Types Applied to Soybeans

| Type | Amish | Non-Amish |
|---|---|---|
| 0-0-60 | N.A. | 1 |
| 3-9-27 | - | 1 |
| 4-10-10 | - | 1 |
| 4-16-27 | - | 2 |
| 4-17-25 | - | 1 |
| 4-17-28 | - | 1 |
| 4-23-18 | - | 1 |
| 4-24-12 | - | 1 |
| 5-20-10 | - | 1 |
| 6-12-12 | - | 1 |
| 6-24-24 | - | 11 |
| 6-26-26 | - | 1 |
| 6-28-10 | - | 1 |
| 6-16-32 | - | 1 |
| 6-32-16 | - | 3 |
| 12-12-12 | - | 3 |
| Beanbuster | - | 3 |
| Total | 0 | 34 |

## Table 8.39 Fertilizer Types Applied to Hay

| Type | Amish | Non-Amish |
|---|---|---|
| 0-32-8 | - | 1 |
| 6-24-24 | 1 | - |
| 15-15-15 | 2 | - |
| Manure | 7 | - |
| Total | 10 | 1 |

In all crop categories, the Amish application of fertilizer is lower than the non-Amish. On many of the crops, an increase in fertilizer for the Amish would make harvest extremely difficult. They want greater crop yields, but are reluctant to apply more fertilizer to get it. The Amish also rely heavily on manure for supplementing their fertilizer. Actually, it is just the reverse, the chemical fertilizer supplements the manure. As can be seen, almost half of the total average pounds of nitrogen per acre comes from manure. We did have two cases of Amish farmers applying 100 pounds of urea (45-0-0) to their crops.

The non-Amish have negligible amounts of manure contributing to their total. The total pounds of nitrogen per acre on silage in table 8.41 is from one farmer. The low figure may be due to misinterpretation of the question in the interview. The amount of fertilizer applied to beans is also variable. One non-Amish farmer reported applying 600 pounds of 8-12-16 per acre.

In terms of cropland, the non-Amish are applying larger amounts of fertilizers to the land than area Amish farmers. The non-Amish account for 83 percent of the cropland in the watershed, whereas the Amish apply virtually all of the manure spread in the watershed and only account for 17 percent of the total cropland.

Tables 8.42 and 8.43 show the amounts of fertilizers being applied across the six sub-watersheds for both Amish and non-Amish. It also indicates where we might expect to find heavy concentrations of chemicals and manure residues in water quality and runoff studies. Among the Amish, their concentration is heaviest in sub-watersheds 1 and 3. The non-Amish dominate the amount of nitrogen per acre in all sub-watersheds with the exception of sub-watershed-1.

Finally, we were interested in knowing when farmers generally applied their fertilizer. In table 8.44, we see that the Amish reported applications mostly at planting with the next largest category being "Spring." Among the non-Amish, applying fertilizers in the fall was first followed by "Spring" and at planting.

Again, we want to emphasize that our comparison of Amish-non-Amish is not meant to be critical of either group of farmers. They both represent different orientations to agriculture and provide an excellent basis for assessing the impact of different agricultural technology to the data obtained in the water quality studies.

### Table 8.40 Total Pounds of Nitrogen and Total Pounds of Nitrogen per Acre by Crop — for Amish

| Crops | Acres in Crop | Yield per Acre | MANURE | | CHEMICAL | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | | | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre | Total lbs of N | Total lbs N/acre |
| Corn (grain) | 587 | 66.0 (bushels) | 8515.0 | 14.5 | 19647.90 | 33.45 | 28162.9 | 47.97 |
| Corn (silage) | 140 | 10.0 (tons) | 1000 | 7.14 | 2760.2 | 19.72 | 3760.2 | 26.86 |
| Soybeans | - | - | - | - | - | - | - | - |
| Oats | 467 | 60.69 (bushels) | - | - | 11480.50 | 24.58 | 11489.50 | 24.58 |
| Wheat | 149 | 23.55 (bushels) | - | - | 4015.0 | 26.95 | 4015.0 | 26.95 |
| Hay | 628 | 2.02 (tons) | 10380.0 | 16.53 | 4677.0 | 7.45 | 15057.0 | 23.98 |
| Pasture | 689 | - | 24500 | 35.56 | 1903.5 | 2.76 | 26403.5 | 38.32 |
| Total | 2660 | - | 44395.0 | 16.68 | 44484.1 | 16.72 | 88879.1 | 33.41 |

Table 8.41 Total Pounds of Nitrogen and Total Pounds of Nitrogen per Acre by Crop — for non-Amish

| Crops | Acres in Crop | Yield per Acre | MANURE | | CHEMICAL | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| | | | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre | Total lbs of N | Total lbs N/acre |
| Corn (grain) | 3709 | 74.05 (bushels) | 205 | .06 | 425178.37 | 114.63 | 425383.37 | 114.69 |
| Corn (silage) | 100 | 20 (tons) | 100 | 1.0 | 3000.0 | 20.0 | 3100.0 | 31.0 |
| Soybeans | 4056 | 28.78 (bushels) | - | - | 15759.6 | 3.88 | 15759.6 | 3.88 |
| Oats | 1382 | 62.68 (bushels) | - | - | 43840.4 | 31.72 | 42840.4 | 31.72 |
| Wheat | 475 | 29.83 (bushels) | - | - | 21002.4 | 42.22 | 21002.4 | 42.22 |
| Hay | 66 | 6.16 (tons) | - | - | - | - | - | - |
| Pasture | 220 | - | - | - | - | - | - | - |
| Total | 10008 | - | 3-5 | .03 | 508780.77 | 50.84 | 509085.77 | 50.87 |

**Table 8.42 Application of Nitrogen and Total Pounds of Nitrogen per Acre by Sub Watershed for Amish Farmers**

| | | MANURE FERTILIZER | | CHEMICAL FERTILIZER | | TOTAL FERTILIZER APPLIED TO LAND | |
|---|---|---|---|---|---|---|---|
| Subwatershed | Acres in SWS | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre |
| #1 | 1354 | 22701.24 | 16.77 | 21982.16 | 16.23 | 44683.40 | 33.00 |
| #2 | 620 | 750.00 | 1.21 | 192.00 | .31 | 942.00 | 1.52 |
| #3 | 1170 | 4311.70 | 3.69 | 10379.49 | 8.87 | 14691.19 | 12.56 |
| #4 | 2080 | 3415.36 | 1.64 | 9787.83 | 4.71 | 13203.19 | 6.35 |
| #5 | 2194 | 7436.02 | 3.39 | 7634.80 | 3.48 | 15070.82 | 6.87 |
| #6 | 4428 | 6066.18 | 1.37 | 3145.29 | .71 | 9211.47 | 2.08 |
| Total | 12038 | 44680.5 | 3.71 | 53121.57 | 4.41 | 97802.07 | 8.12 |

Table 8.43 Application of Nitrogen and Total Pounds of Nitrogen per Acre by Sub Watershed for non-Amish Farmers

| | | MANURE FERTILIZER | | CHEMICAL FERTILIZER | | TOTAL FERTILIZER APPLIED TO LAND | |
|---|---|---|---|---|---|---|---|
| Subwatershed | Acres in SWS | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre | lbs of N | lbs N/ acre |
| #1 | 1354 | - | - | 7496.75 | 5.54 | 7498.75 | 5.54 |
| #2 | 620 | 40.76 | .07 | 29789.82 | 48.05 | 29830.58 | 48.12 |
| #3 | 1179 | 65.90 | .06 | 42741.05 | 36.53 | 42806.95 | 36.59 |
| #4 | 2080 | 40.24 | .02 | 301375.56 | 144.89 | 301415.80 | 144.91 |
| #5 | 2194 | 11.43 | .01 | 75469.11 | 34.40 | 75480.54 | 34.41 |
| #6 | 4428 | 146.67 | .03 | 181301.49 | 40.94 | 181448.16 | 40.97 |
| Total | 12038 | 305.0 | .025 | 638175.78 | 53.01 | 638480.78 | 53.035 |

**Table 8.44 When Do You Apply Fertilizer**

| Season | Amish | | Non-Amish | |
|---|---|---|---|---|
| | N | % | N | % |
| Fall | 3 | 9.4 | 23 | 40.4 |
| Spring | 7 | 21.9 | 14 | 24.6 |
| Before Planting | - | 0.0 | 2 | 3.5 |
| At Planting | 17 | 53.1 | 12 | 21.1 |
| After Planting | 3 | 9.4 | 2 | 3.5 |
| N/R | 2 | 6.3 | 4 | 7.0 |
| Total | 32 | 100.0 | 57 | 100.0 |

## 4. SUMMARY

In reflecting on this last year's work, we find we are constantly learning how to work more effectively with the Amish. Some difficulties have been experience for various reasons. First, the Amish are suspicious of our methods and fear we are going to ask them to do something contrary to their beliefs. However, as we learn to understand the Amish culture and how to operate within it, we can suggest alternative measures that will not cause them embarrassment. Second, some of the changes we asked the Amish to undertake are really more drastic to them than what we think. Moving or tearing down fences, rotating within a field rather than between fields and raising the plow to cross grassed waterways, rather than cutting through are hard for the Amishman to understand. Leaving field borders, although conservationally speaking, it is very acceptable, the Amishman says, "That means cutting off four rows of corn on that field which is two loads of corn. How will I make that back on the rest of the field?"

Third, the Amish have smaller parcels of land than do non-Amish (as a rule) and therefore, we are more likely to have more group decisions when involving Amish in conservation projects in the watershed. These group decisions take more time and require more effort by project personnel. Fourth, their being bi-lingual with German (and the project personnel not), creates some difficulties in knowing what objections are really holding them back from participating. At times, we think we have all the necessary ground-work laid for a decision when they begin conversing in German. Whether they are for or against the project is difficult for the project member to ascertain. If the Amishman is raising an objection, it is impossible for the project person to meet that objection when the Amishmen are conversing in German. In spite of these potential problems, however, the cooperation thus far is better than expected.

Some of these problems, although focusing most heavily on the Amish are also found among the non-Amish. The difference is that we can more easily identify the Amish as a group and refer to their culture as a contributing factor. Yet, when we observe non-Amish farmers preparing their fields, we did not notice many fields with field borders wider than a couple feet. Therefore, although we have not as yet worked as extensively among the non-Amish, we should expect to find some of the basic objections.

Education programs are being prepared for the Amish to bring them up to an awareness that help is available on many farm related problems. Purdue Extension Specialists have participated in horticulture schools, and others are being developed in livestock management and production. Then, the Amish should be ready for a series of meetings on the importance of soil conservation.

Finally, we sometimes do not realize the social significance behind some of the changes introduced by the project. When a pond was put in behind the Graber farm, it was intended for agricultural purposes (watering livestock) and some conservation of wildlife. It also was expected to be used for recreational purposes by the family. We have observed, however, that during the summer months when the youth are hot and tired from making hay, etc., that the pond serves as a community gathering place. All the youth, not only in the watershed, but in surrounding church districts come to the Graber pond to swim. In fact, it is not uncommon to stand in the farmyard and watch the buggies come in loaded with the family and innertubes, ready to swim. This provides an opportunity for other Amishmen to visit with the Grabers and although it may not be stated, nevertheless, they all know the pond was a result of the project. Therefore, the social activities support the leadership structure among the Amish (Mr. Graber is one of their ministers) and patterns of influence are expected to operate in the same manner among the Amish as described in figure 8.1 in Part I on Leadership Among the Non-Amish.

# *Local Administration Benefits Project*

**SECTION 9**
**Management of Black Creek Sediment Control Project**

By
## James Lake

Managing a project such as the Black Creek Project with the many disciplines that are involved is a very complex and challenging opportunity. The project organization encompasses two federal agencies, U.S. Environmental Protection Agency and the U.S. Soil Conservation Service, one university, Purdue; several state organizations, Department of Natural Resources, State Soil and Water Conservation Committee, State Board of Accounts, and the Allen County Soil and Water Conservation District which itself is a sub-unit of the state government. Also involved in the project are several county offices including the County Surveyors Office, County Highway Department, County Plan Commission and the County Data Processing. Most importantly more than 200 private landowners of the Black Creek watershed are involved. Therefore, communication is probably the most important factor in attempting to manage the activities of the Black Creek Study. Figure 9.1 shows the organization of personnel involved in the project. As manager it is my responsibility to see to it that information flows smoothly between various department and agency heads in order that everyone knows what is happening at all times. This is a very difficult task since there are so many small studies being conducted by individuals to help fulfill the large project objectives. In order to maintain the necessary communication, monthly Steering Committee meetings are held at the Project Office. At these monthly meetings all personnel involved in the project are expected to attend and exchange information pertaining to project activities.

One of the real handicaps in attempting to manage a study over five years is personnel changes by cooperating agencies. Several of the people involved in the pro-

**ORGANIZATION**
**of**
**PROJECT PERSONNEL**

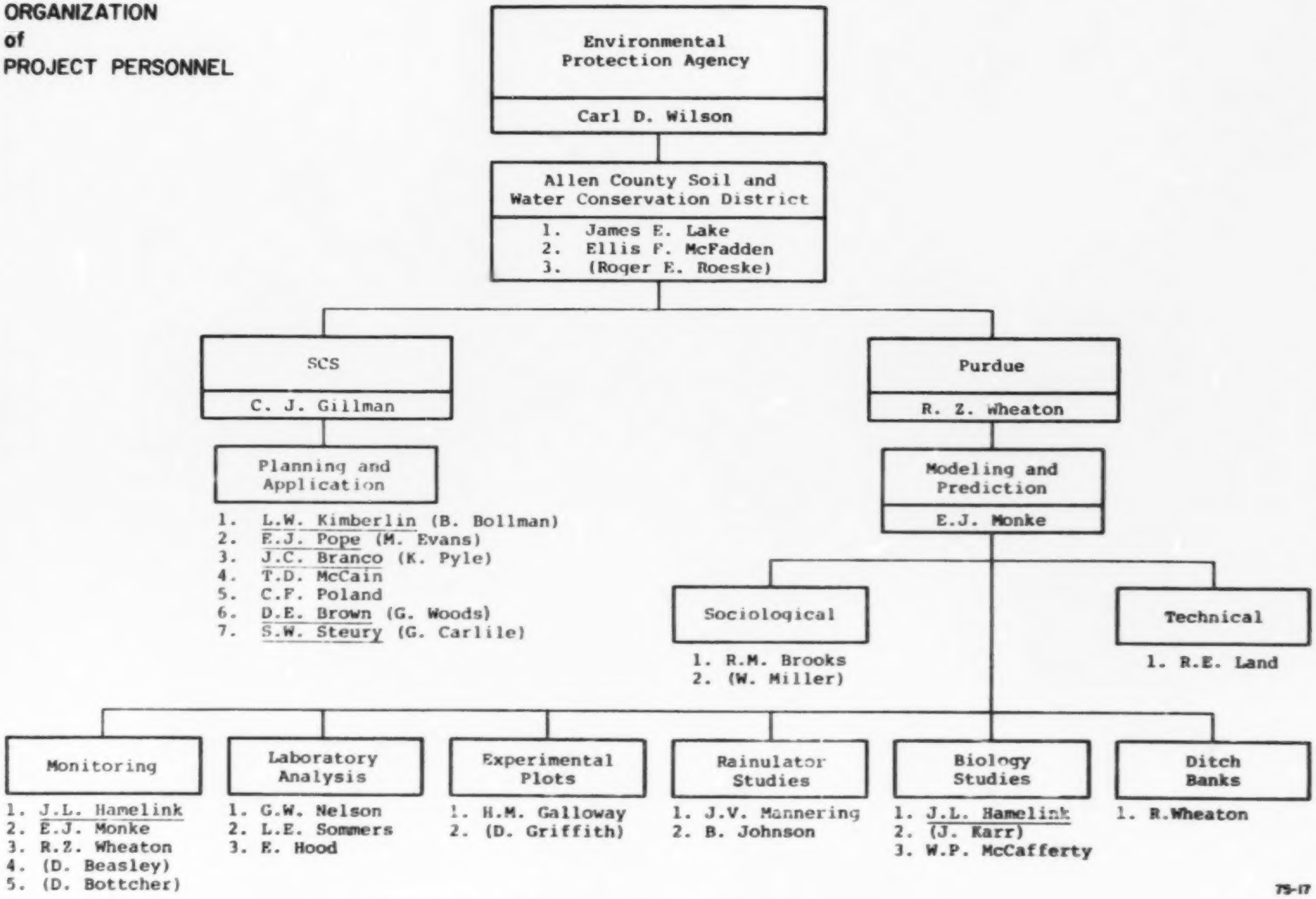

Environmental Protection Agency
Carl D. Wilson
Allen County Soil and Water Conservation District
1. James E. Lake
2. Ellis F. McFadden
3. (Roger E. Roeske)
SCS
C. J. Gillman
Planning and Application
1. L.W. Kimberlin (B. Bollman)
2. E.J. Pope (M. Evans)
3. J.C. Branco (K. Pyle)
4. T.D. McCain
5. C.F. Poland
6. D.E. Brown (G. Woods)
7. S.W. Steury (G. Carlile)
Purdue
R. Z. Wheaton
Modeling and Prediction
E.J. Monke
Sociological
1. R.M. Brooks
2. (W. Miller)
Technical
1. R.E. Land
Monitoring
1. J.L. Hamelink
2. E.J. Monke
3. R.Z. Wheaton
4. (D. Beasley)
5. (D. Bottcher)
Laboratory Analysis
1. G.W. Nelson
2. L.E. Sommers
3. E. Hood
Experimental Plots
1. H.M. Galloway
2. (D. Griffith)
Rainulator Studies
1. J.V. Mannering
2. B. Johnson
Biology Studies
1. J.L. Hamelink
2. (J. Karr)
3. W.P. McCafferty
Ditch Banks
1. R.Wheaton
75-17

Figure 9.1 Organization of Project Personnel

ject at its beginning are no longer with the project; therefore, several new names appear in figure 9.1. Names of people who have left the project are underlined, and the new personnel names are included in parentheses.

In general things have progressed quite well with this multi-disciplinary approach to demonstrating the affects of land use and land use activities on water quality. This project is generating many firsts and this may very well be one of the first times that so many agencies cooperated to attack a mutual problem and were able to conduct their activities so smoothly. This can be attributed to the fact that the project is being directed by the Soil Conservation District whose organizationl structure allows it to be the hub through which all other agencies as well as private landowners can conduct their business efficiently. The district is small in staff size but it is large in the area of people it can work with. Because of its size the district is able to conduct business with private landowners and with other agencies without the bureaucratic red tape that is so often involved in government. This is a very important factor in trying to conduct a study as complex as the Black Creek Study over a five-year period. The efficiency of this project to date can be attributed to district supervision.

## 1. FINANCIAL MANAGEMENT

### A. Overall Costs Versus Budget

The Black Creek Project was estimated to cost $2.5 million of which $1.8 million would be received from the U.S. Environmental Protection Agency with a 25 percent match generated from local sources. As with everything else, costs have been consistantly higher than was previously expected. However, we have managed to conduct the study to date within the originally allocated budget as can be seen on figure 9.2. Several internal transfers of money have been necessary, however, to do so. For example, money may have been taken with permission from the project officer, from supplies appropriation and placed in the equipment appropriation to cover the higher than anticipated equipment costs. Money was also appropriated based on a yearly estimate, it has been necessary at times to transfer money from one year to another in order to cover expenditures. In looking closely at figure 9.2, one can see that expenditures were not as high in the early stages of the project as was expected. In order to revise the budget for 1974 and 1975, money was taken from the appropriations for 1972 and 1973. The budget most seriously underestimated was that of the district. As can be seen in figure 9.3, only $22,000 was appropriated for the entire district project costs. It was soon recognized that the staff placed in the project office was not adequate to meet the demands of the project. Personnel from the Soil Conservation Service were not adequate to handle the increased number of landowner requests and engineering requirements generated from this accelerated land treatment program. Rather than attempt to refinance in order to place more Soil Conservation Service personnel in the project office it was decided by the district board of supervisors to hire our own additional staff to meet the demands. Therefore, money was transferred from the land treatment portion of the project to the district budget in order that a district professional engineer could be hired. This revised increase cost is reflected on figure 9.3. The district felt that this was sound expenditure in that there would be no delays in getting the man placed in the project office and that there would be no future problems such as transfers, and relocations. By hiring its own employee, the district felt it would have more control of the operations at the project office level through the duration of the project. As can be seen in figures 9.4 and 9.5, both Purdue and the Soil Conservation Service were able to keep project expenditures within the original appropriation. The only minor changes in the budgeting for these sub-contractors were a few transfers of money from the early years of the project to later years in the project.

## B. Land Treatment Goals Versus Accomplishments Versus Expenditures

The most important aspect of the entire Black Creek Project is the application of practices on private land in order to monitor the affects of land treatment on water quality. A total of $750,000 was committed to land treatment activities. These funds were to be used as cost-share incentives to landowners for the installation of needed conservation practices. This figure was not arrived at by accident. A team from the Soil Conservation Service studied the entire Black Creek watershed area during the development of the work plan and set up goals for each of 34 different conservation practices identified as needed in the Black Creek area. These goals were based on soil types and agricultural land uses, which existed in the watershed at the beginning of the project. These goals were based on 100 percent accomplished land treatment over the entire watershed area. Unit average cost were established for each practice, and a budget was set up for each practice based on the goal and the unit cost. The total goal for land treatment times the unit cost for these practices is approximately $1 million. Since it was decided it would cost $1 million for total land treatment in the watershed area and the district determined that it would like its average cost-share incentive to the landowners to be 75 percent of total cost, a figure of $750,000 was placed in the budget for cost-sharing to private landowners for land treatment. Figures 9.6 through 9.38 illustrate the goals by year, the planned commitment for application, the total accomplished to date (bar graph), and an original cost sharing funds appropriated by practice. In analyzing these figures it is obvious that in most cases the goal is significatly higher than committments or accomplishments. There are a few cases, (see grade stabilization structures, figure 9.14, and stream channel stabilization, figure 9.28) where the accomplishments and expenditures exceed the original estimate. This is very gratifying. These two practices were installed at a faster rate than originally expected. Other practices that have been applied at very high levels are conservation cropping (figure 9.6), critical area planting (figure 9.10), field borders (figure 9.12), grassed waterways (figure 9.13). Despite the accelerated application of thesepractices, 100 percent of the goal has not been reached on any of them. This indicates that either the goals were originally set too high or that there is more required to obtain concentrated land treatment than providing technical assistance and cost sharing assistance.

Several practices have been quite discouraging, such as contour farming (figure 9.7), farmstead and feedlot windbreak (figure 9.11), field windbreak (figure 9.13), land smoothing (figure 9.17), minimum tillage (figure 9.20), pasture and hayland planting (figure 9.22), sediment control basin (figure 9.26), strip cropping (figure

9.30), tree planting (figure 9.33), and woodland practices (figures 9.35 and 9.37).

Some of these practices are admittedly not very adaptable to the Black Creek watershed area. Farmers have been very reluctant to accept these practices even with high levels of cost-sharing incentives.

One practice which causes concern is minimum tillage. Minimum tillage is frequently cited as a key to lowering erosion in the Maumee Basin area. Even though minimum tillage sounds like a very promising erosion control technique, it has not been readily accepted by farmers. Sufficient research and demonstration on minimum tillage on the heavy lake bed type soils to encourage and educated the farmer to attempt to using the technique has not been conducted. When farmers are convinced that minimum tillage will not reduce yields and lower income, they will be more willing to adapt. If they can be shown that minimum tillage will save them money, as well as soil it will be readily acceptable basinwide. This points out the need for further education and demonstration along with good research in the area of minimum tillage. It has often been said that if funds were made available at a level high enough to insure the farmer, high levels of cost-sharing assistance, many practices which have been encouraged by the Soil Conservation Service for years would be installed rapidly. We are learning from the Black Creek project that even when sufficient funding is available for cost-sharing assistance and sufficient technical assistance is provided to the farmer for proper installation of conservation practices, another factor becomes important — the decision by the private landowner as to the suitability of practice on his farm. If the farmer is not willing to install the practice or cannot see any value in applying certain practices, no level of funding will be sufficient to encourage application of a particular practice. Planning, technical assistance, and adequate financial cost-sharing may not beall that is needed to assure adequate land treatment.

## 2. MAINTENANCE

In developing the format and procedure for conducting the Black Creek Study, the cost of necessary maintenance on the project application throughout the duration of the project was not adequately considered. Any time that a large amount of land treatment is accomplished in a concentrated watershed area, a certain amount of maintenance is unavoidable. This became very evident in the spring of 1975 when on May 20, the watershed received a 4½-inch rain over a period of 2½ hours. This was equivalent of a 100-year rain. Many of the practices which were installed were able to handle the severe stress, however there were areas where excessive damage did occur. Also other practices have shown evidence of needing continual maintenance. One shortcoming of using federal funds for cost-sharing assistance is that the landowners are quite willing to accept funds for new practices and new construction on their land; however, when the greater amount of the money spent for those practices comes out of the federal dollar rather than their own it is quite difficult to encourage them to spend the necessary money to maintain these practices once installed.

More than $200,000 has been spent in large construction, along the main Black Creek channel and its tributaries. Each year there is the need for several thousand dollars worth of maintenance. Private individuals often feel that roads, ditches and many other services should be provided to them at no cost.

The usual procedure in Allen County for drainage maintenance is through land assessments by the County Surveyor's office to cover the cost of maintenance on legal drains. People in the Black Creek area often feel that money that has already been spent by them for the reconstruction of the Black Creek drain is all they should have to spend, and that the county should maintain the drain. This creates difficulty for the surveyor. Due to our experimental and sometimes elaborate project work, we have created higher costs for maintaining the drainage system in the Black Creek watershed. In looking back at the development of the Black Creek Project one would probably insist that so many dollars be set aside for maintenance costs to cover the cost of necessary repair work that comes about during a project of this type. If a project like Black Creek is to be conducted again, maintenance should be considered as a very high priority in the program organization. In order to get a feel for the type of maintenance that is inevitable, following construction like that completed in the Black Creek area. C. F. Poland, Area Engineer, S.C.S., and John Dennison, Area Engineering Technician prepared a maintenance report on the Black Creek main channel which is included as an appendix. Included in their report is a description of the conditions of the Black Creek channel prior to the May 20 storm followed by a discussion of the conditions that were left after this one heavy rainfall event. Included in the report is a map, which locates the area discussed.

## 3. PLANS FOR COMING YEAR

### A. Land Treatment

Several things are being considered to improve the land treatment accomplishments in the coming year, including employment of another district employee to contact landowners who have a plan for applying conservation practices sometime during the program period. The follow-up specialist being considered would spend his time seeing to it that scheduled land treatment practices are actually installed. Our experience in the past has been that unless the farmer is contacted during the critical times when installation of the practices must be accomplished, landowners may overlook the practice and delay installing it. The hiring of a follow-up specialist would probably increase the amount of actual practice installation significantly. Since there are only two construction seasons left in the project period, a strong follow-up program is essential.

The original scope of the project was to start planning on the west side of the watershed area progressing eastward until the entire watershed was canvassed. Data collected by Purdue have indicated that it is going to be difficult to recognize water quality changes as a result of land treatment activities. Therefore, the district has directed soil conservation personnel to concentrate planning activities on the Dreisbach Drain located on the west side of the watershed in order to maintain the highest concentration of land treatment possible. Hopefully this will give Purdue every chance possible to detect any results of concentrated land treatment in a subwatershed area. Further land treatment over broad areas of the watershed would not be significant to the monitoring program. In order to attempt to gain a high level of land treatment in the Dreisbach Drain subwatershed, the district has increased its cost sharing rates on several critical erosion control practices.

As of next year, grass waterways, terraces, sediment control basins and several other erosion control practices most significant to the upland areas of the watershed will be cost-shared at 90 percent. This gives Soil Conservation Service planners a chance to recontact landowners who were not cooperative in the early stages of the program to see if they can encourage them to cooperate with the higher cost-share incentives. Purdue will attempt to detect through their data collection any water quality change that can be attributed to land treatment in the area of heavy application versus the areas in the eastern portion of the watershed where application of land treatment practices have been avoided. It is important to note, however, that the subwatershed, Dreisbach in the western portion of Black Creek has a large concentration of rolling upland soils. The eastern portion of the Black Creek area has a large concentration of level lake bed soils. Therefore land treatment practices are needed much greater in the Dreisbach area. One thing that concerns both the district and the representatives doing the modeling and predictions for Purdue is that to date it has been very difficult to even relate land treatment activities to water quality results. Hopefully some correlation can be detected in the coming years.

## B. Research

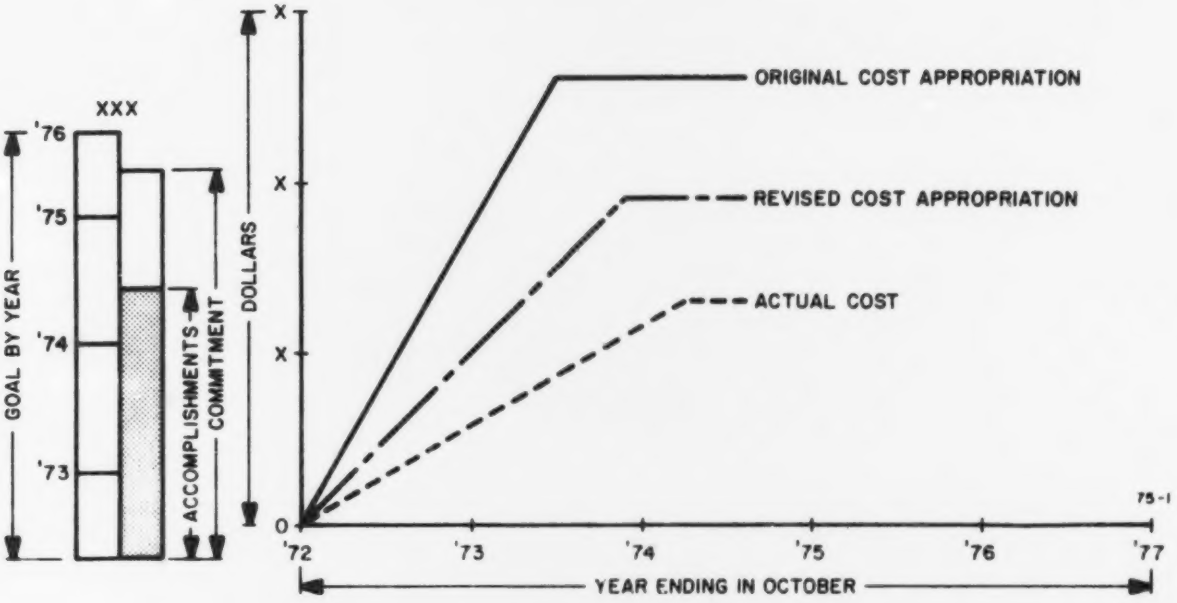
In order to improve and expand the research and monitoring activities being conducted by Purdue University, three new programs will be started in the coming year. The first is a real time, on-line monitoring network for the automatic sampler stations in the Black Creek watershed. Dr. Larry Huggins has been awarded a contract from The Environmental Protection Agency as a part of the Black Creek project to install a complete weather station in the watershed area as well as a dedicated telephone line system which will relate direct information from the monitoring sites in the Black Creek watershed area to the computer terminal at the Purdue Lafayette campus. This will enable Purdue to automatically record the weather events as well as to rely on the automatic sampling system around the clock. It will also allow Purdue to have better control over when samples are taken. For example, the automatic samplers are now triggered by the volume of flow coming over a weir, with the new real time monitoring system Dr. Huggins will be able to increase the number of samples that can be taken on the upside of the hydrograph and reduce the number of unnecessary samples taken on the downward side of the hydrograph. This new project will have a significant influence on the quality of data being collected in Black Creek area.

Another aspect to be undertaken during the next year is that of automatically sampling the tile drainage flow. Del Bottcher, a graduate assistant under Dr. Edwin Monke, has developed a pumping sampler which will sample the flow from tile drainage systems. Initial studies of tile drainage flows have indicated that there are measurable amounts of soil being carried through the drainage tile systems. By installing the automatic tile sampler, the quality and quantity of the samples will improve significantly. This will enable Purdue to pinpoint the amount of sediment that can be attributed to tile drainage transport.

The third change in the research and demonstration effort by Purdue University which will be seen next year relates to conservation tillage research. Our efforts in the last two years have been through small demonstration plots on several sites in the Black Creek area. This approach has proven to be rather unsuccessful because of the lack of controlled research with the small demonstration plots. The farmers who have cooperated with these small plot trials have not been interested to the point of maintaining a quality control. Without having replicated plots, the information being obtained from the small single plot trials has been almost useless in terms of research data. In order to improve this program, Dr. Don Griffith, a Purdue minimum tillage specialist, has requested the district to rent several large plots of approximately 20 acres each. This will allow Purdue to place a man in the watershed area to supervise and actually install the minimum tillage trial. This effort will involve the purchase of a tractor and planter and other equipment necessary to farm and maintain these research plots. The large plots will allow replicated trials sufficient to provide research data. If these plots are successful, they should serve as excellent educational tools which will help to encourage minimum tillage in the future. This more expanded approach to conservation field trials could hold many answers to the future successes or failures pertaining to minimum tillage in the Maumee Basin area.

## 4. SUMMARY

In summarizing the activities of the Black Creek Project to date, one can be quite satisfied and pleased with the accomplishments that have been recorded. Many needed answers will be obtained from the work being conducted on this project. This project should provide the type of information that is needed for future decisions relating to land use and water quality. As director of the Black Creek Project I am looking forward with great anticipation to the activities of the coming year, and I am appreciative of the great effort and cooperation that has been received from all participating agencies and private landowners. May this project be one for which we can all be proud of for many years to come.



KEY TO FIGURE 9.2 THROUGH 9.38

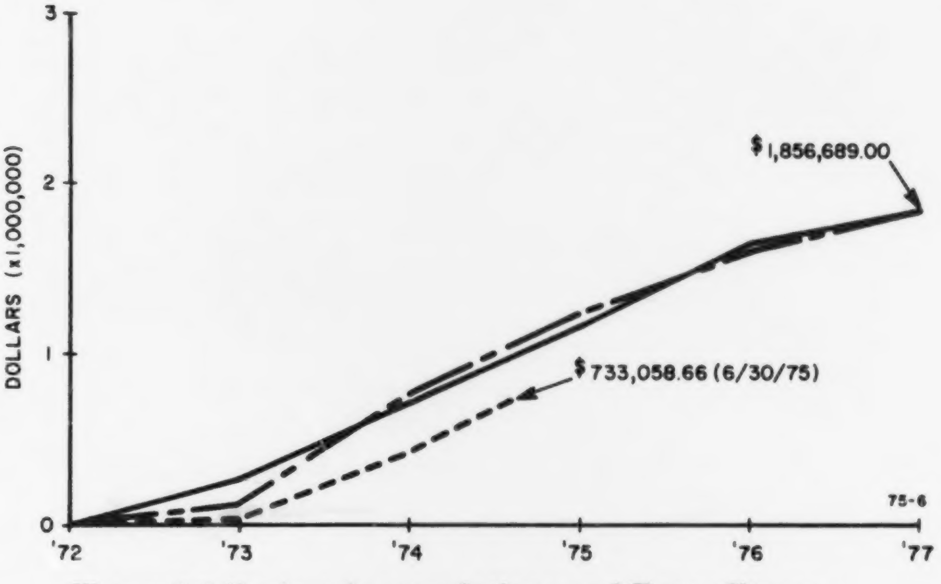


**Figure 9.2 Project Appropriations and Expenditures**

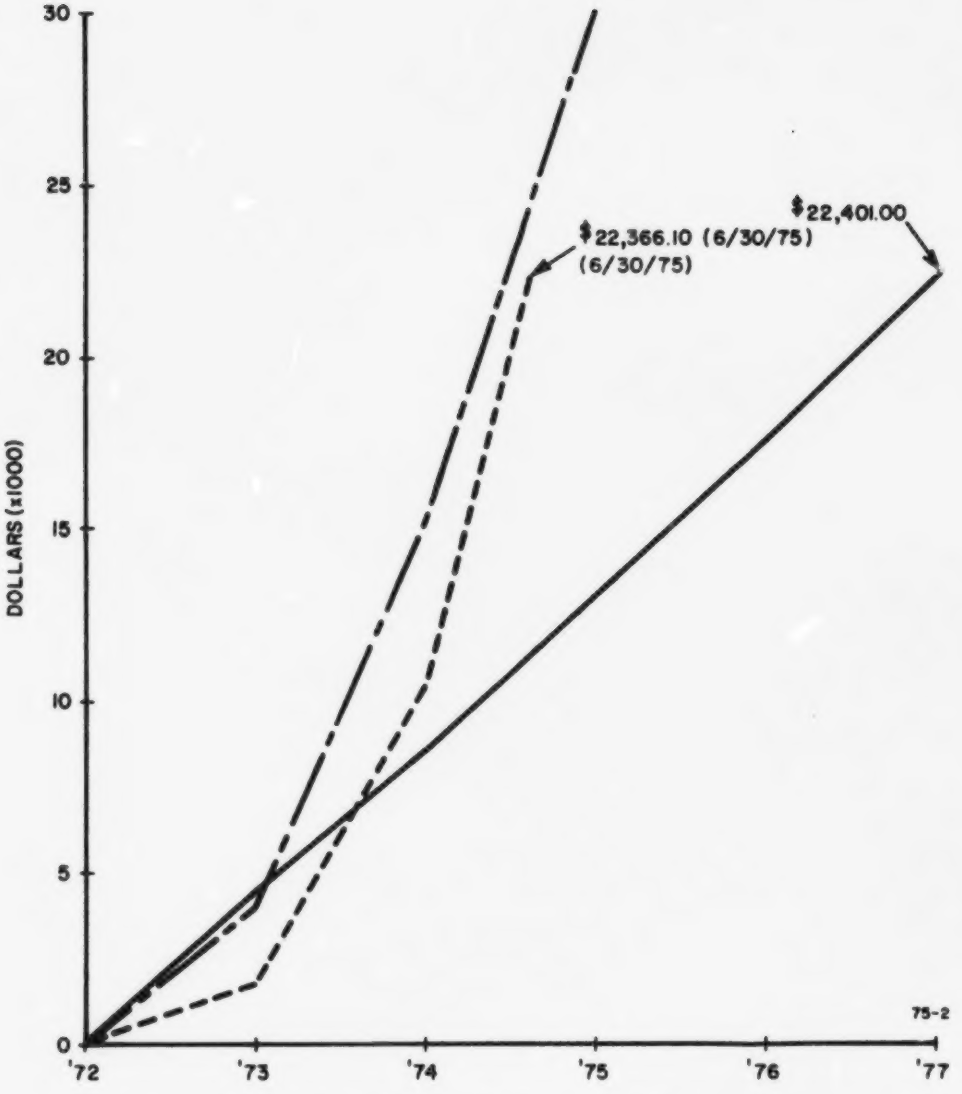


Figure 9.3 District Appropriations and Expenditures

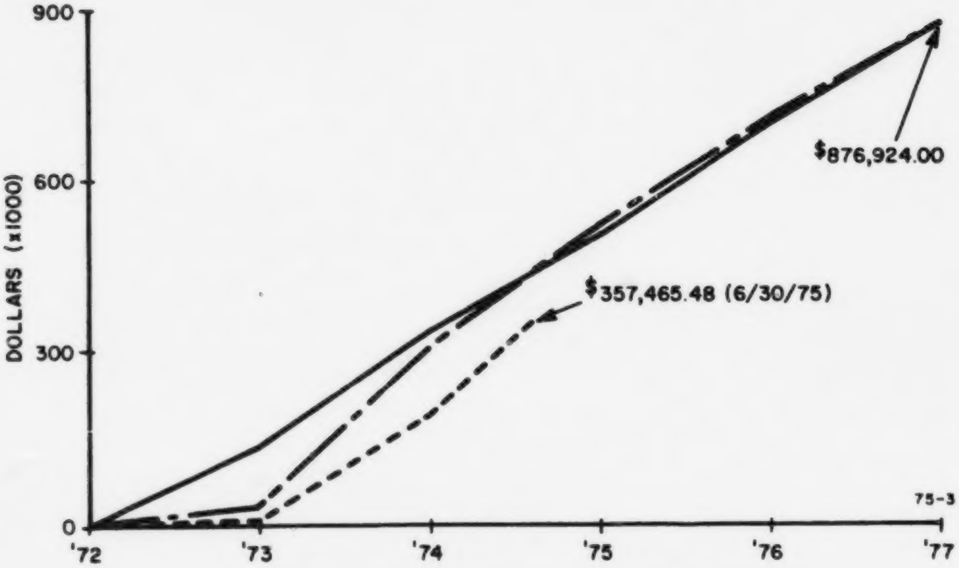


Figure 9.4 Purdue Appropriations and Expenditures

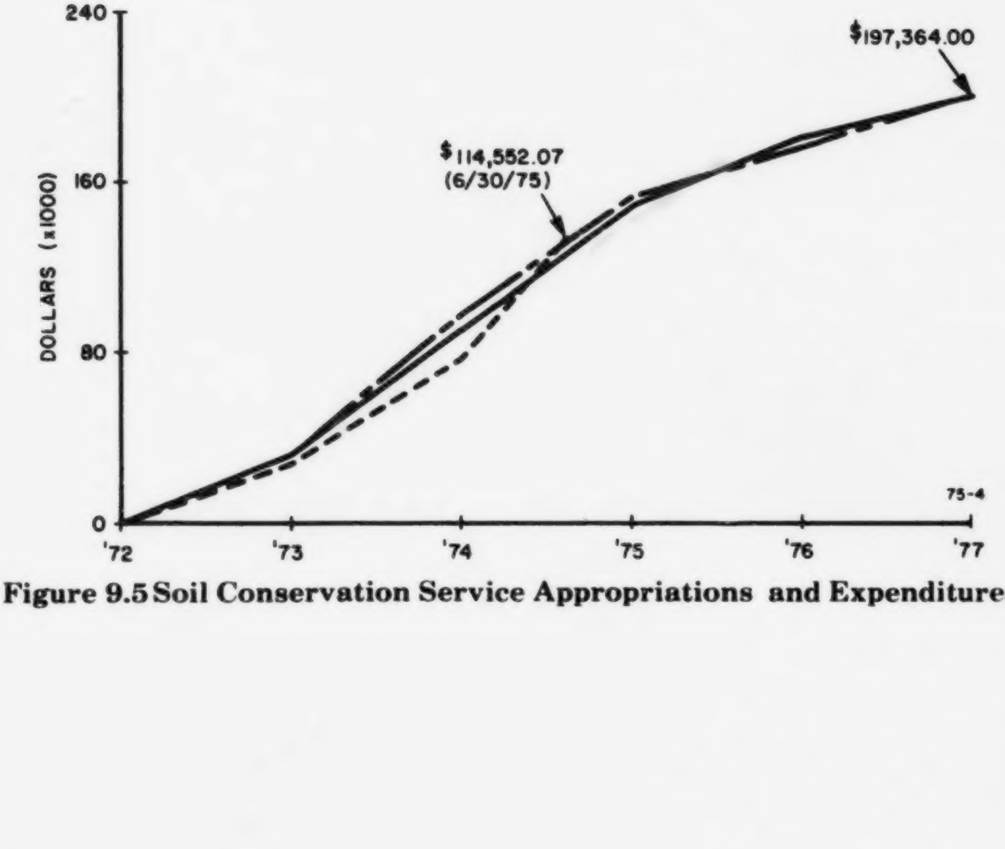


Figure 9.5 Soil Conservation Service Appropriations and Expenditures

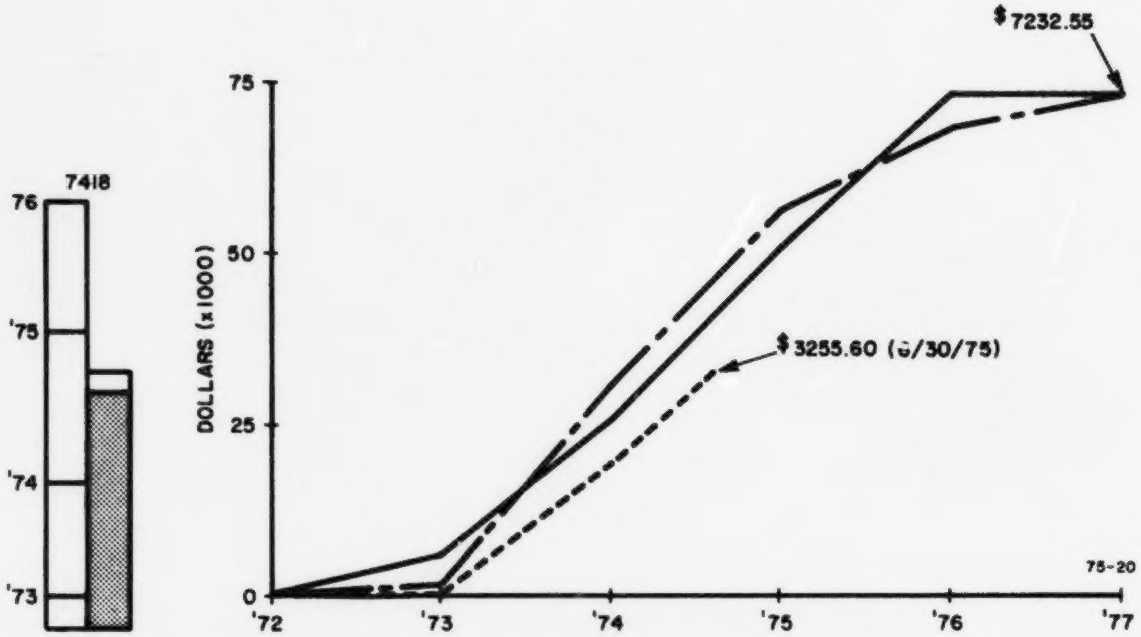


Figure 9.6 Conservation Cropping System

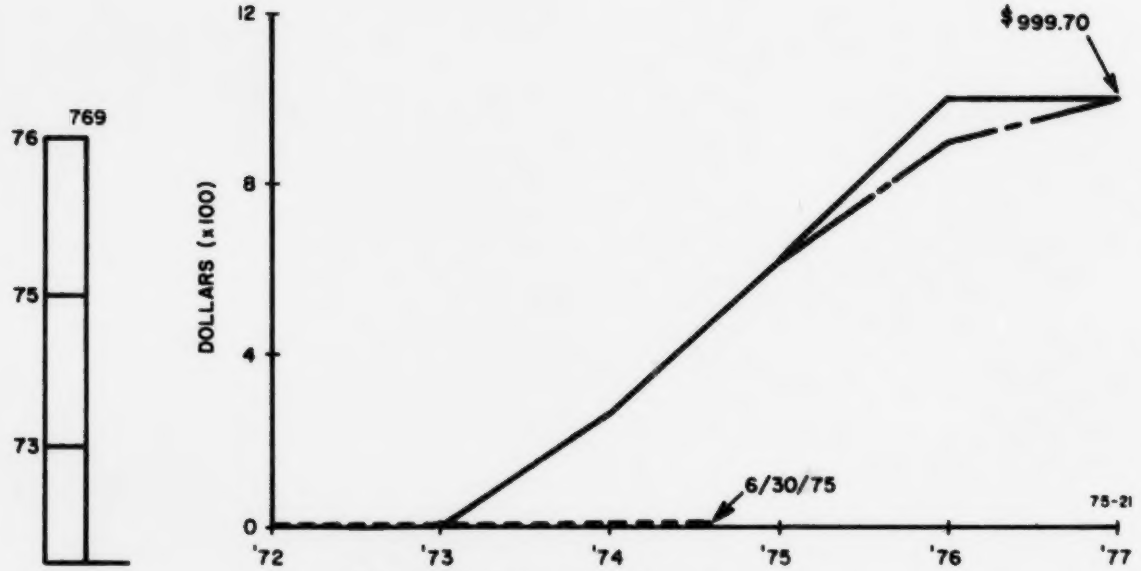


Figure 9.7 Contour Farming

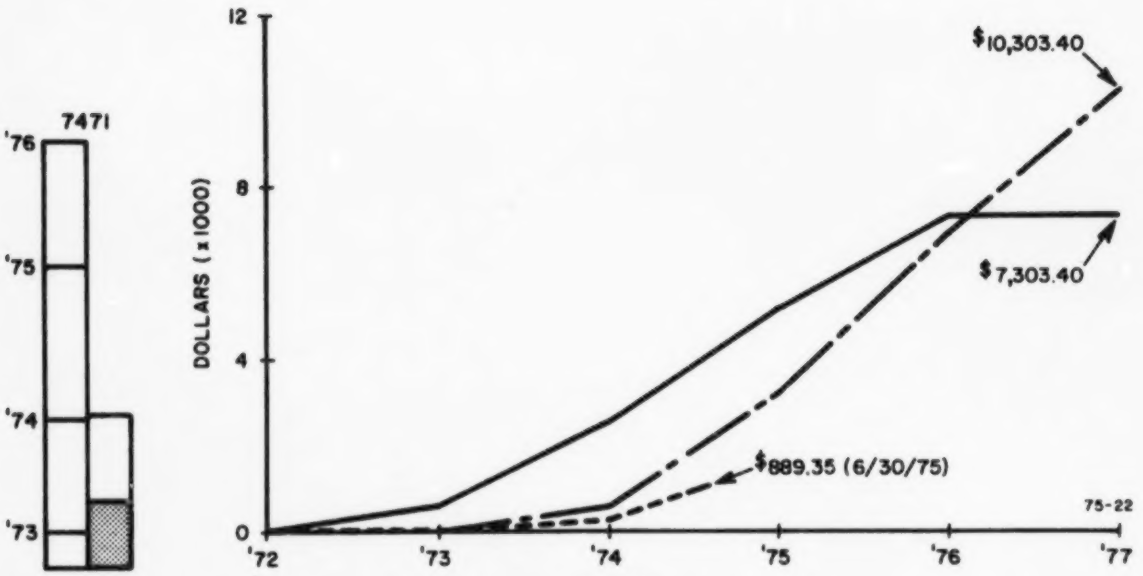


Figure 9.8 Crop Residue Management

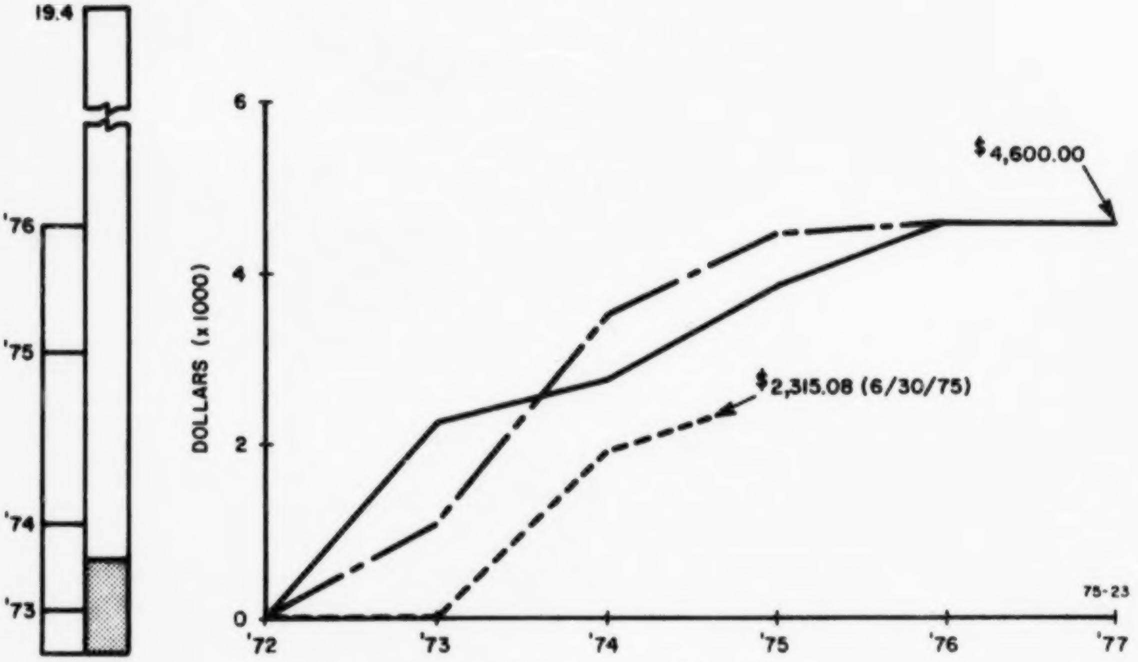


Figure 9.9 Critical Area Planting

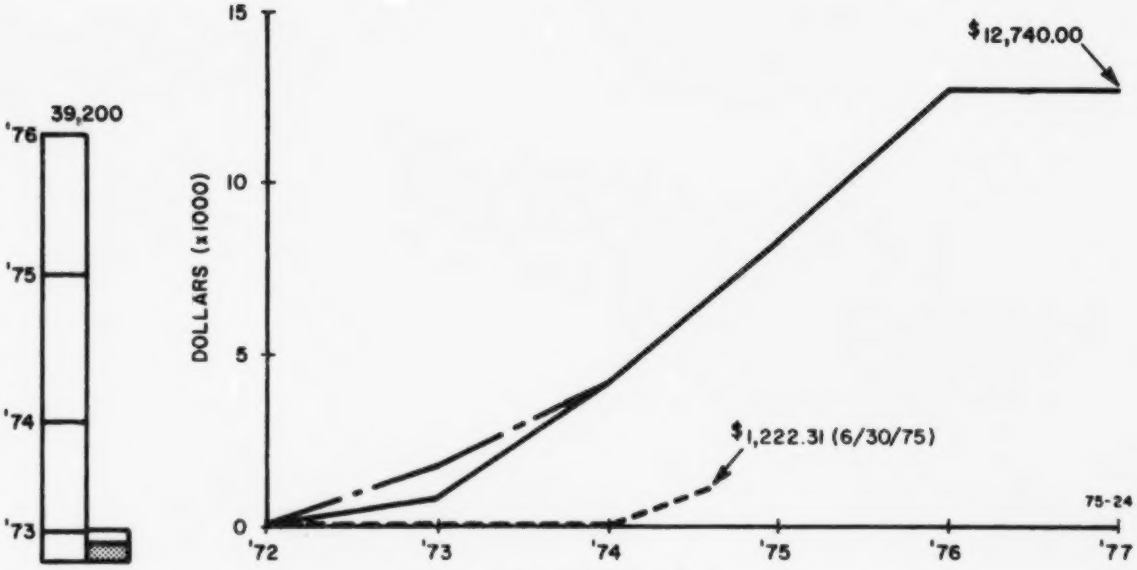


Figure 9.10 Diversion

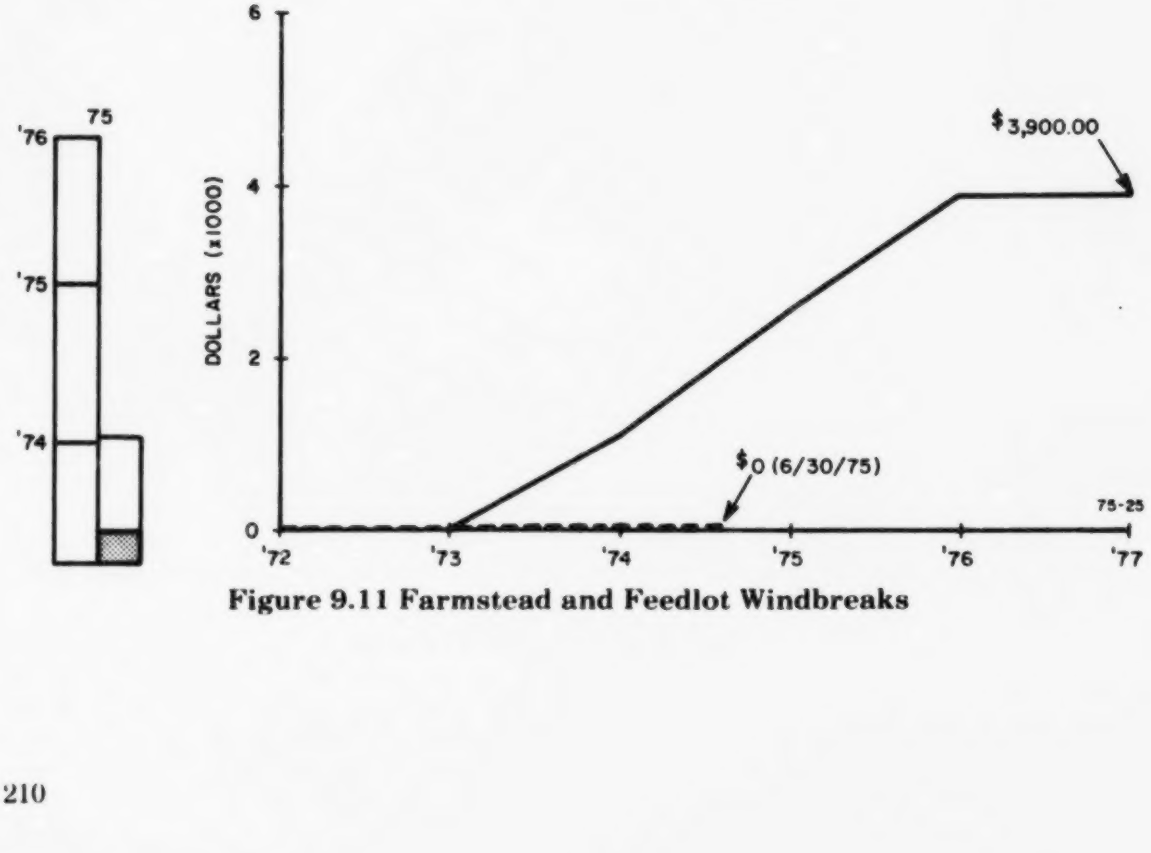


Figure 9.11 Farmstead and Feedlot Windbreaks

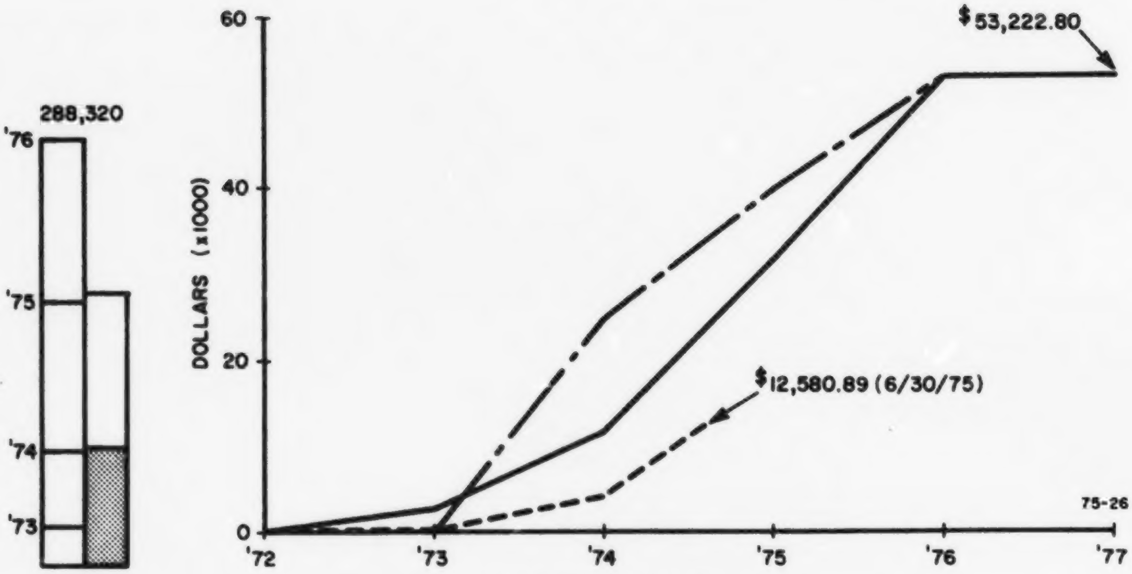


Figure 9.12 Field Border

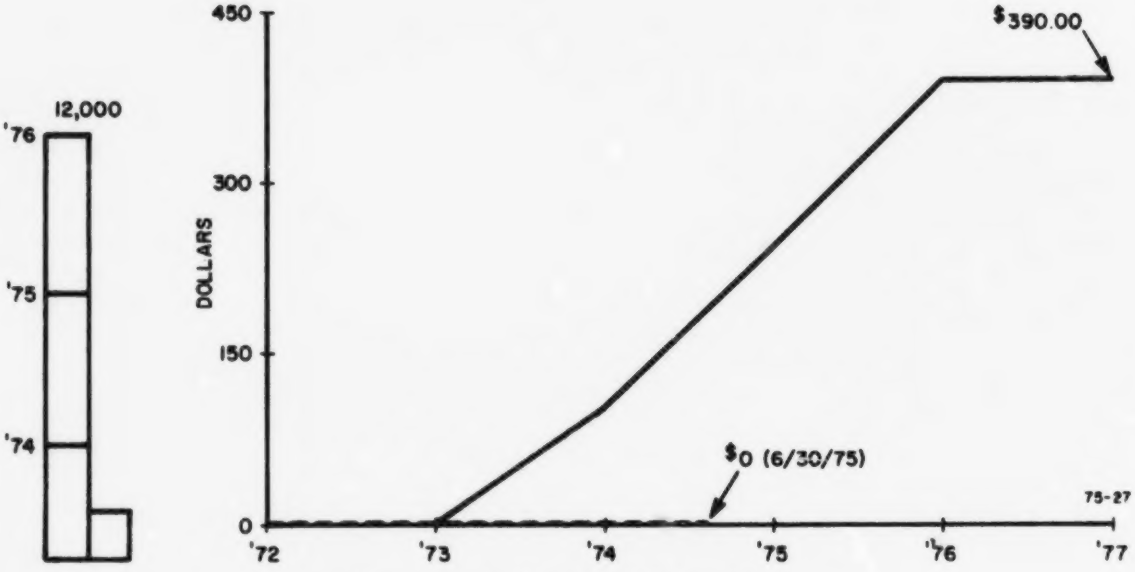


Figure 9.13 Field Windbreaks

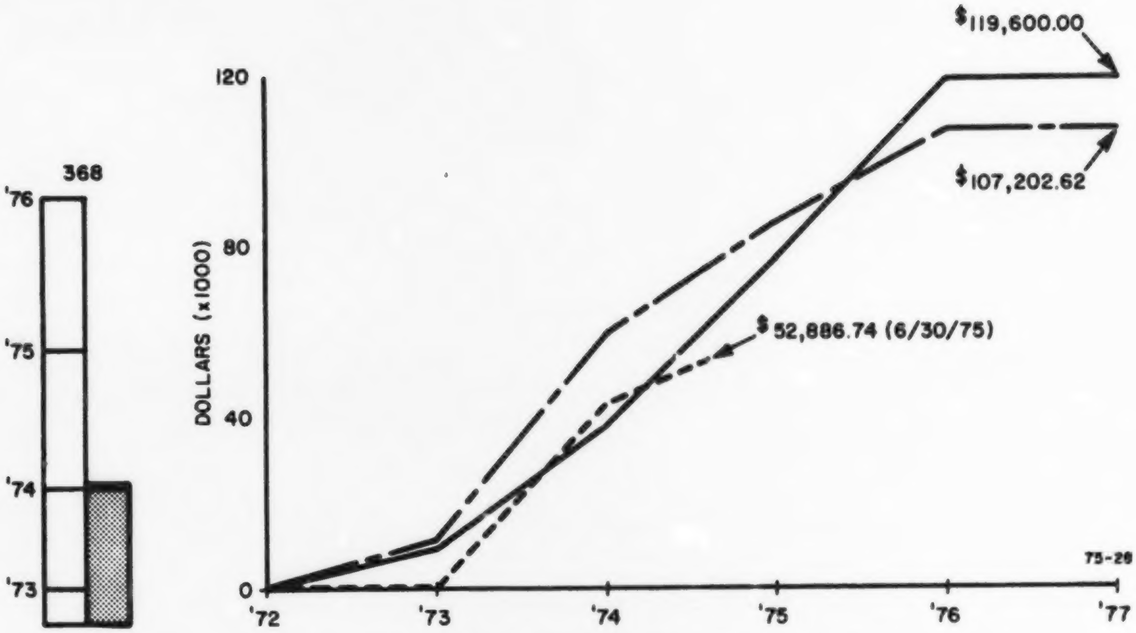


Figure 9.14 Grade Stabilization Structure

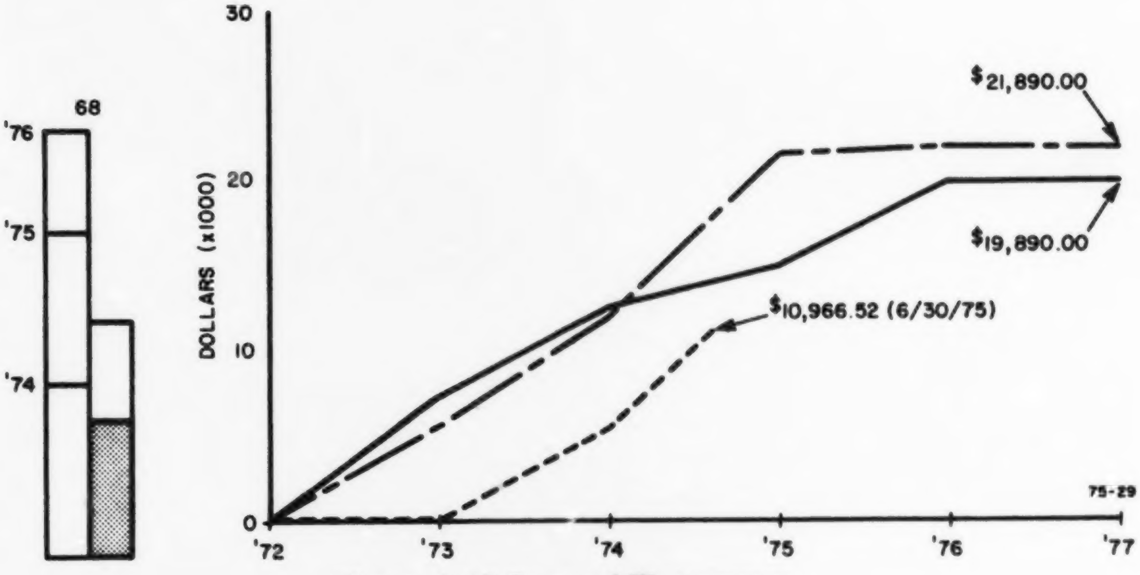


Figure 9.15 Grassed Waterways

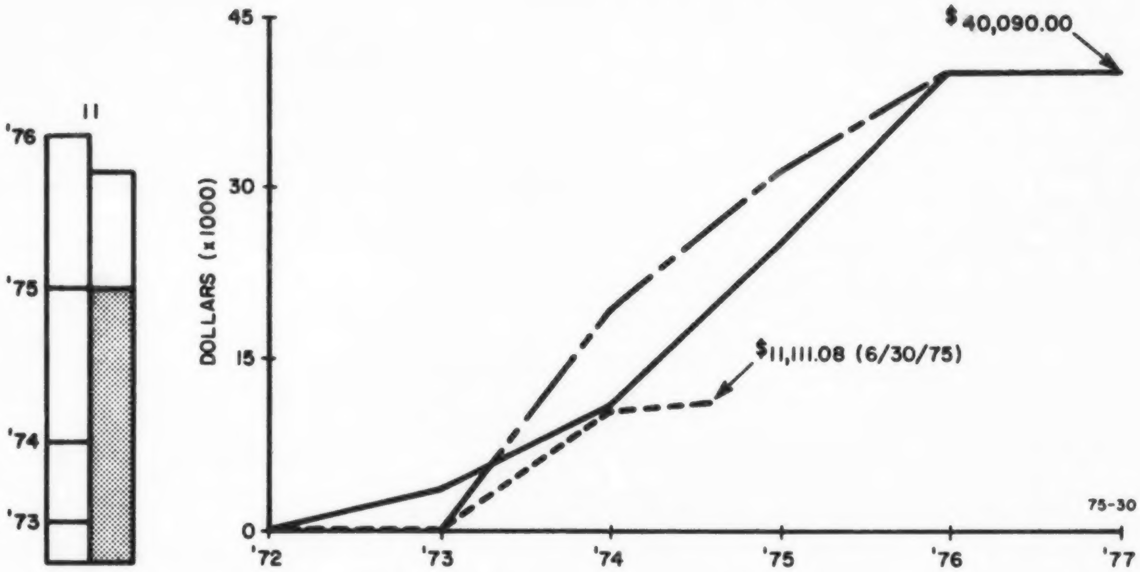


Figure 9.16 Holding Ponds and Tanks

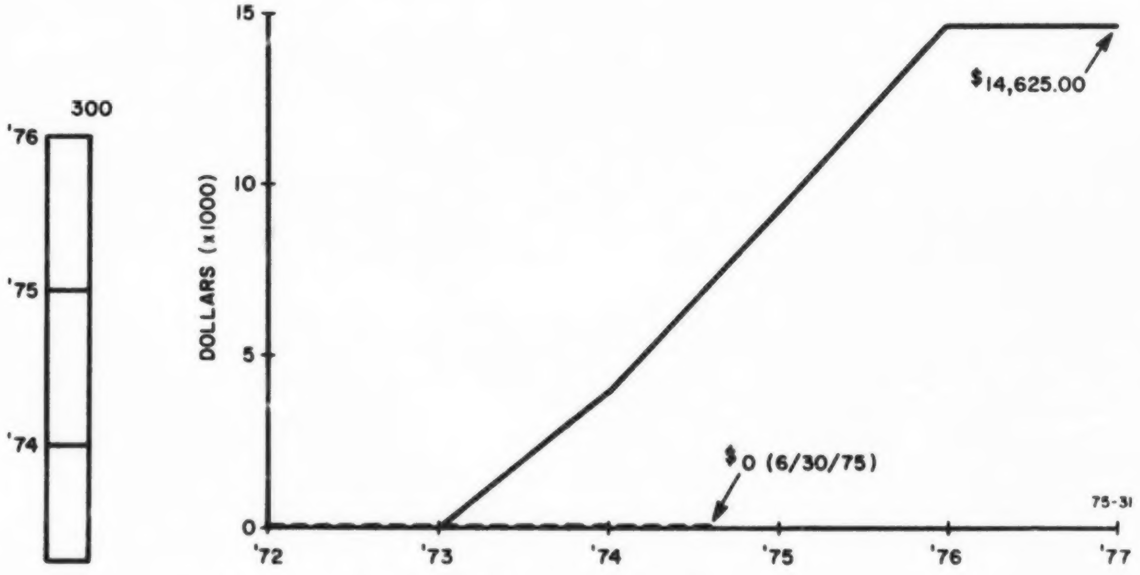


Figure 9.17 Land Smoothing

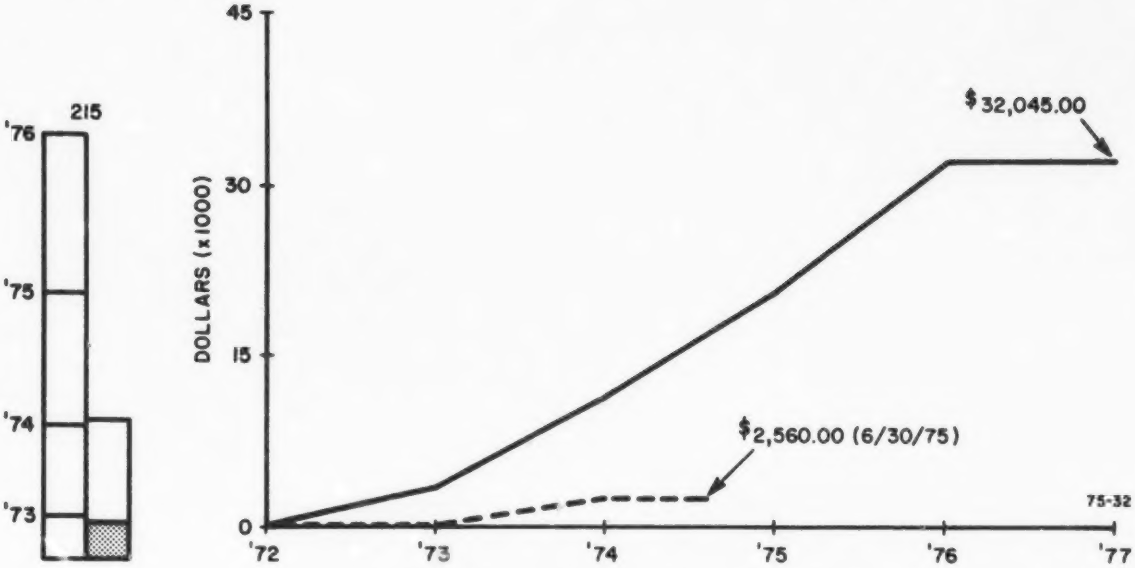


Figure 9.18 Livestock Exclusion (fencing)

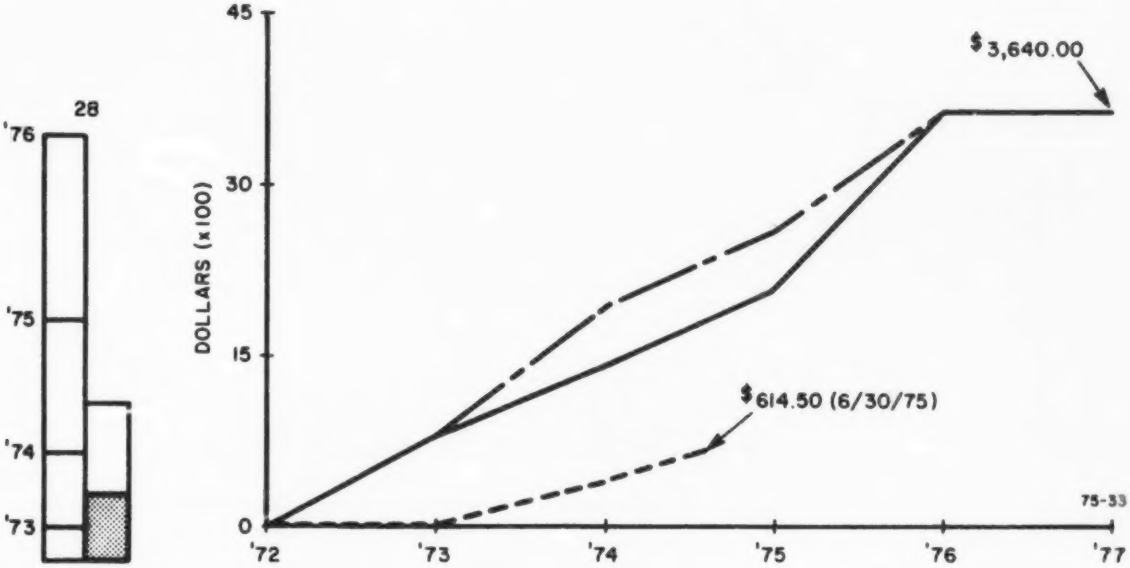


Figure 9.19 Livestock Watering Facility

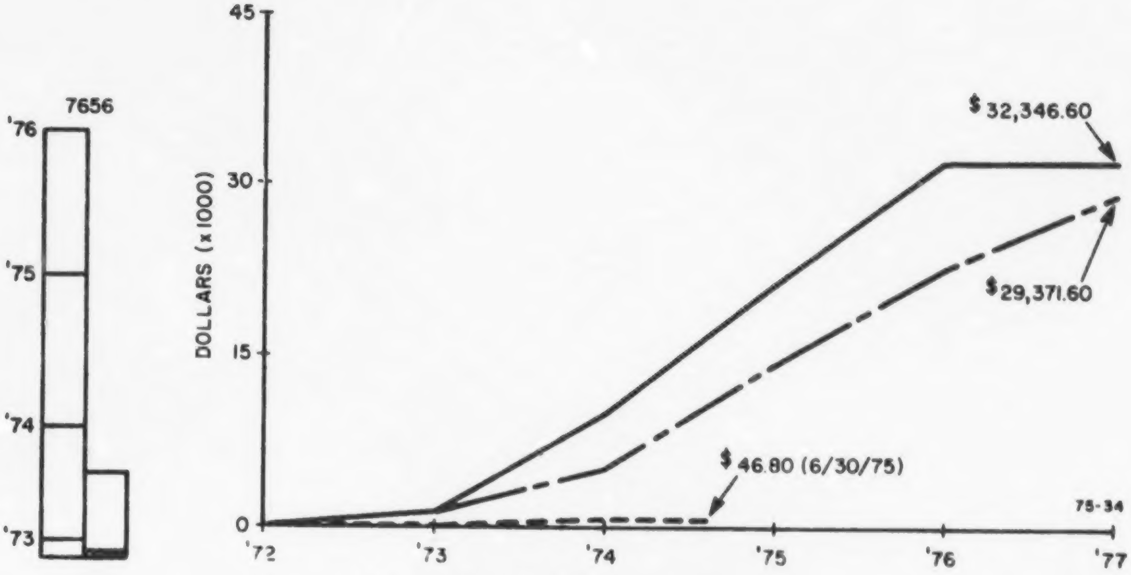


Figure 9.20 Minimum Tillage

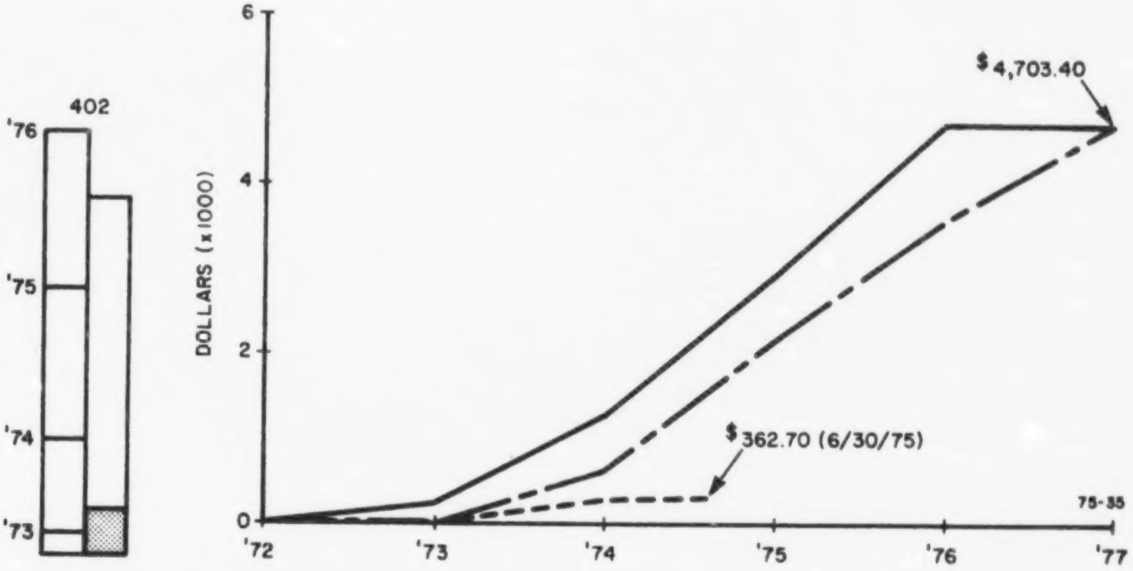


Figure 9.21 Pasture and Hayland Management

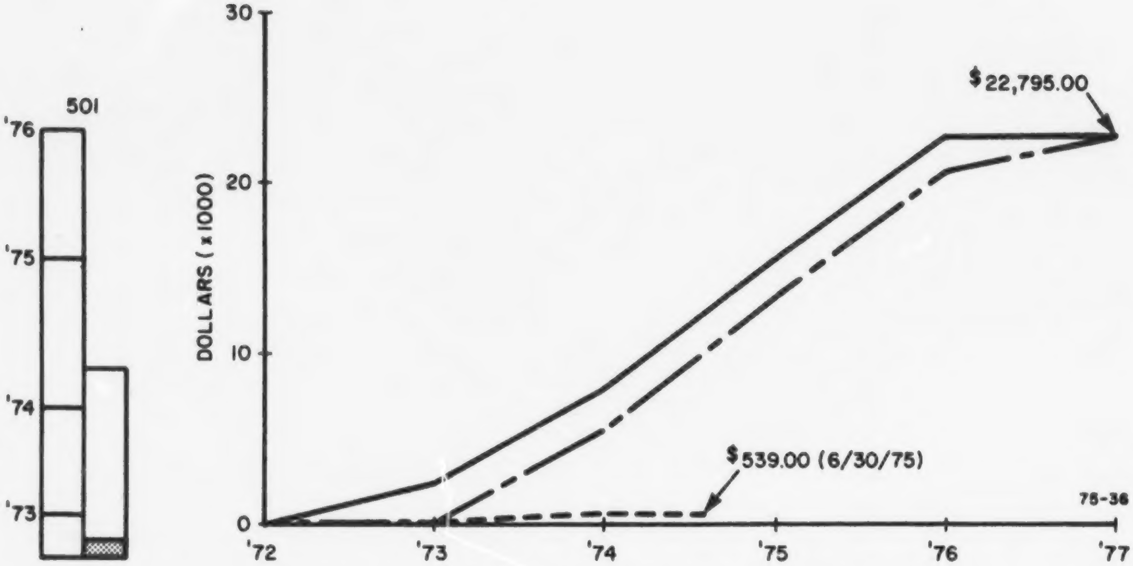


Figure 9.22 Pasture and Hayland Planting

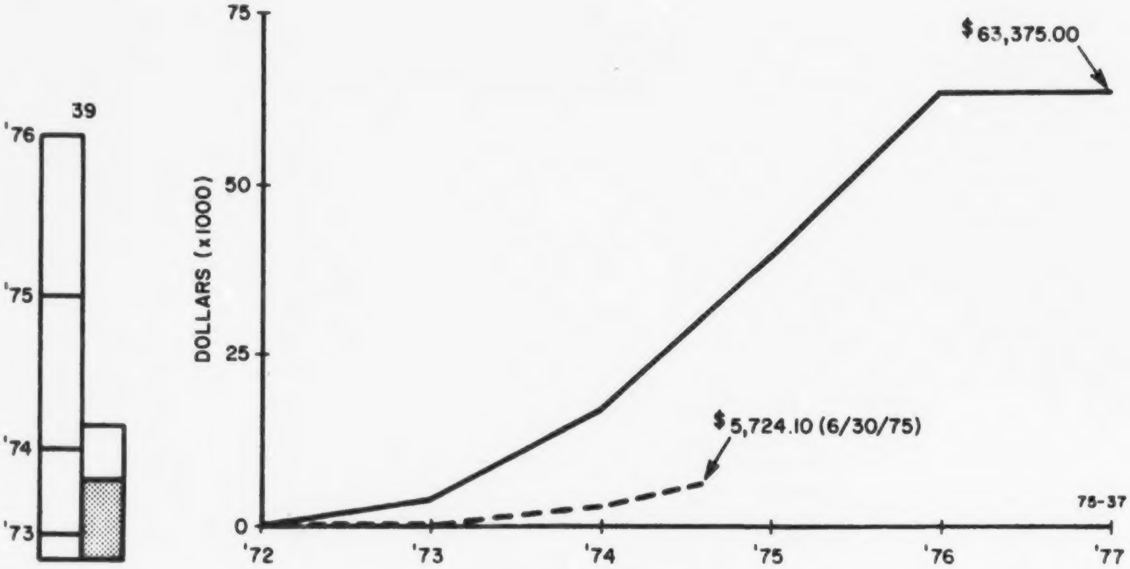


Figure 9.23 Pond

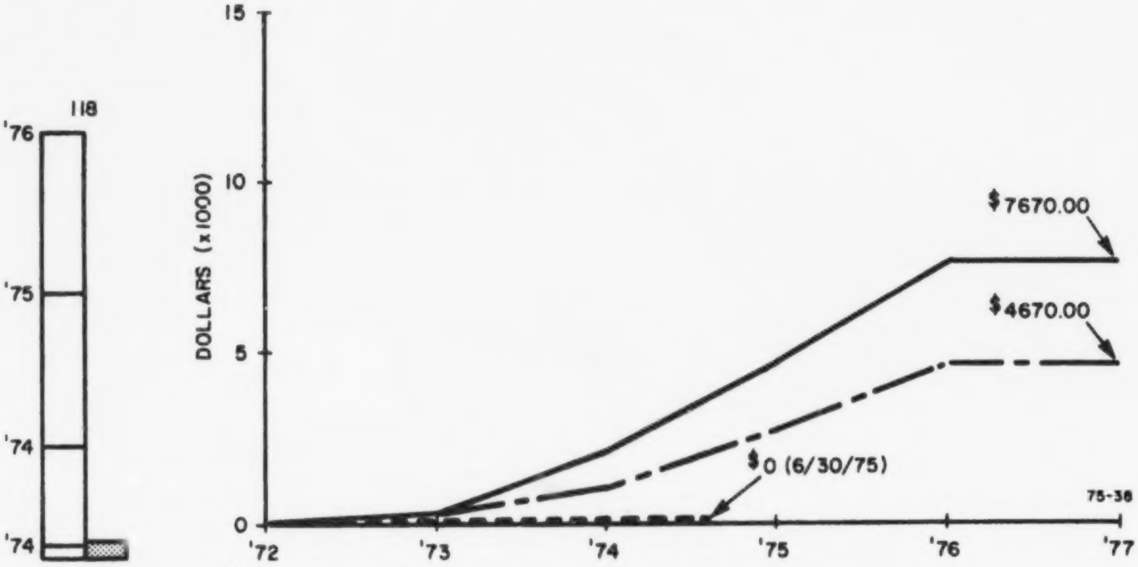


Figure 9.24 Protection During Development

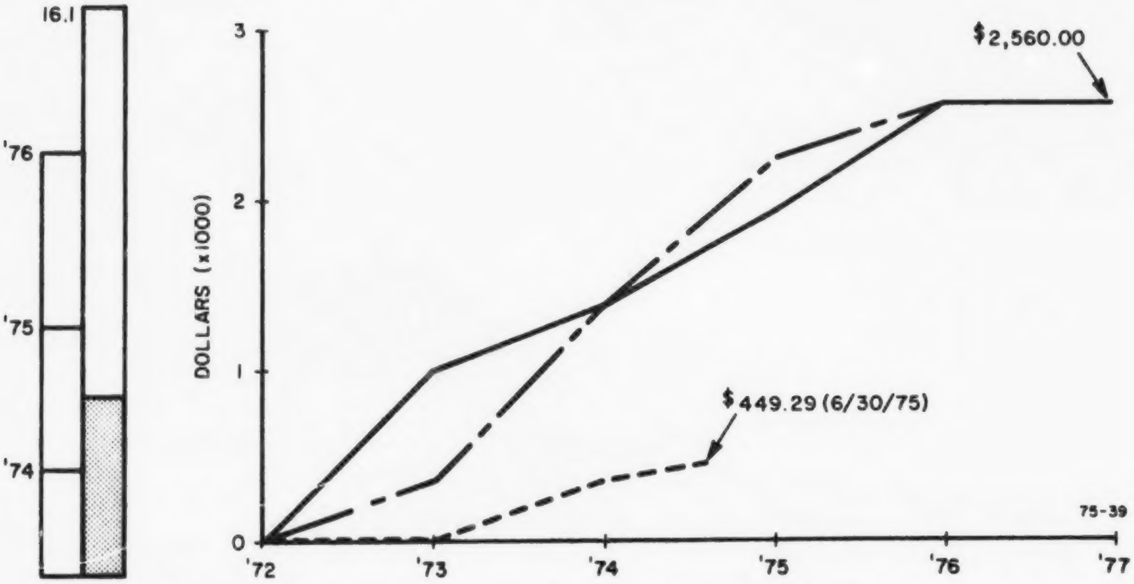


Figure 9.25 Recreation Area Improvement

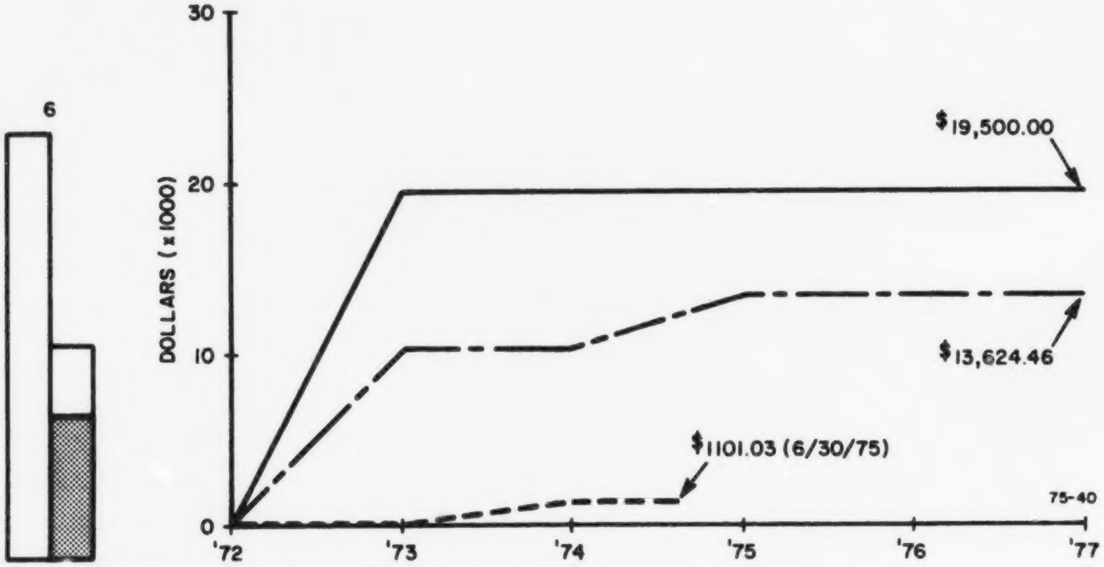


Figure 9.26 Sediment Control Basins

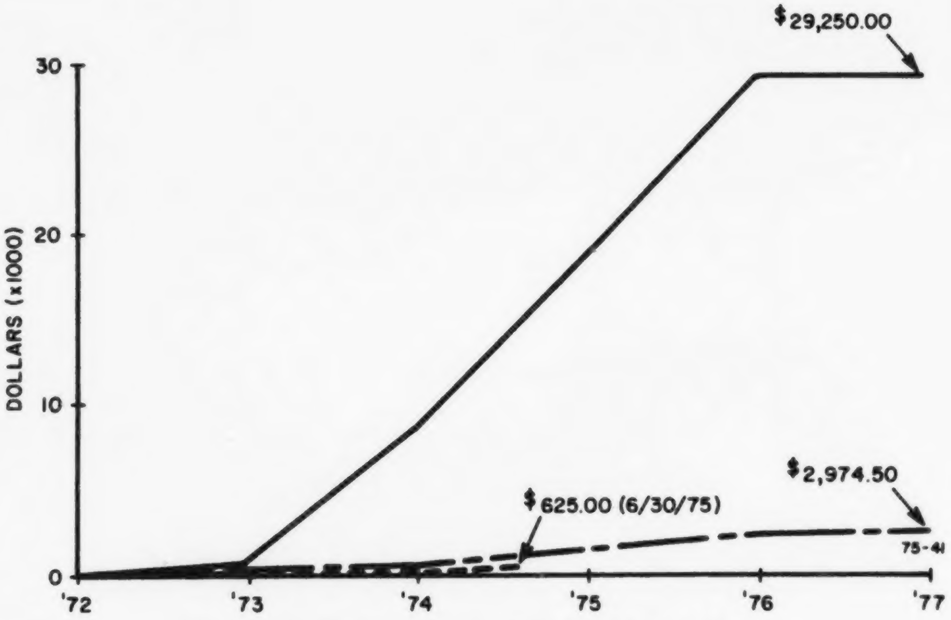


Figure 9.27 Conservation Field Trials

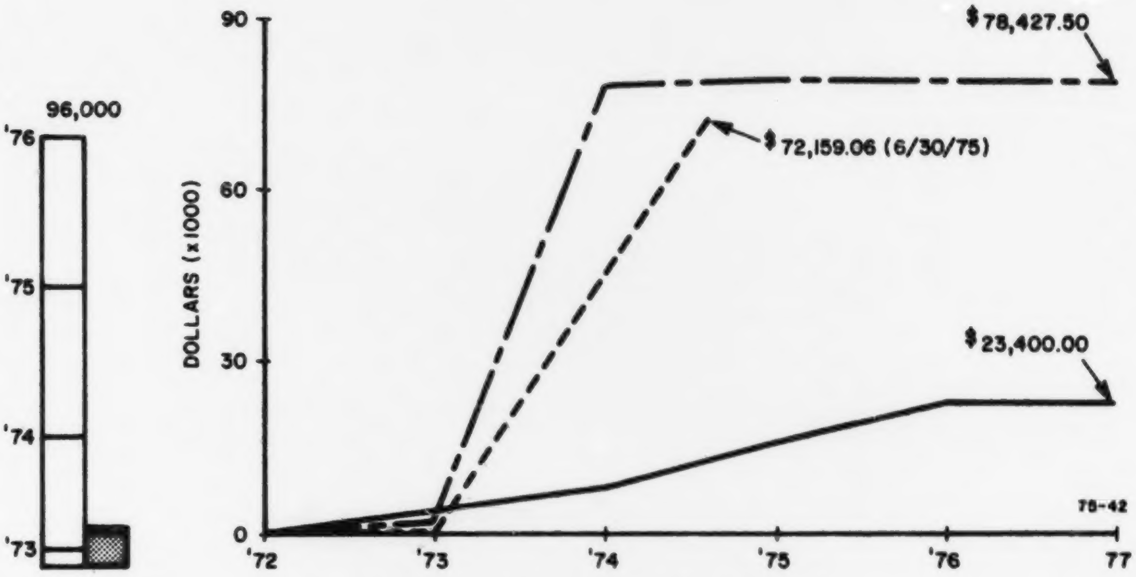


Figure 9.28 Stream Channel Stabilization

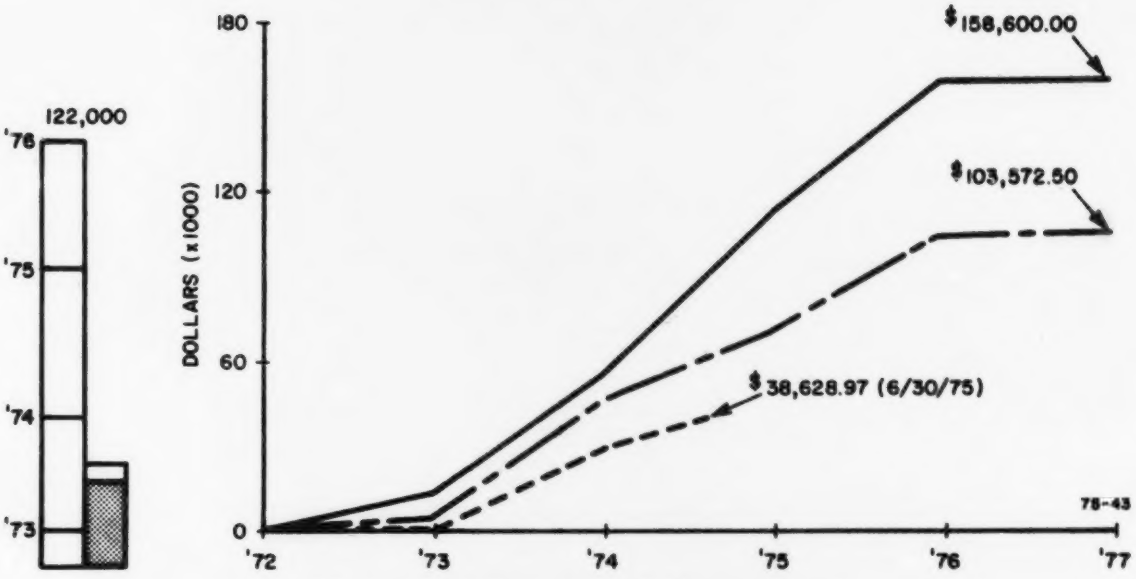


Figure 9.29 Streambank Protection

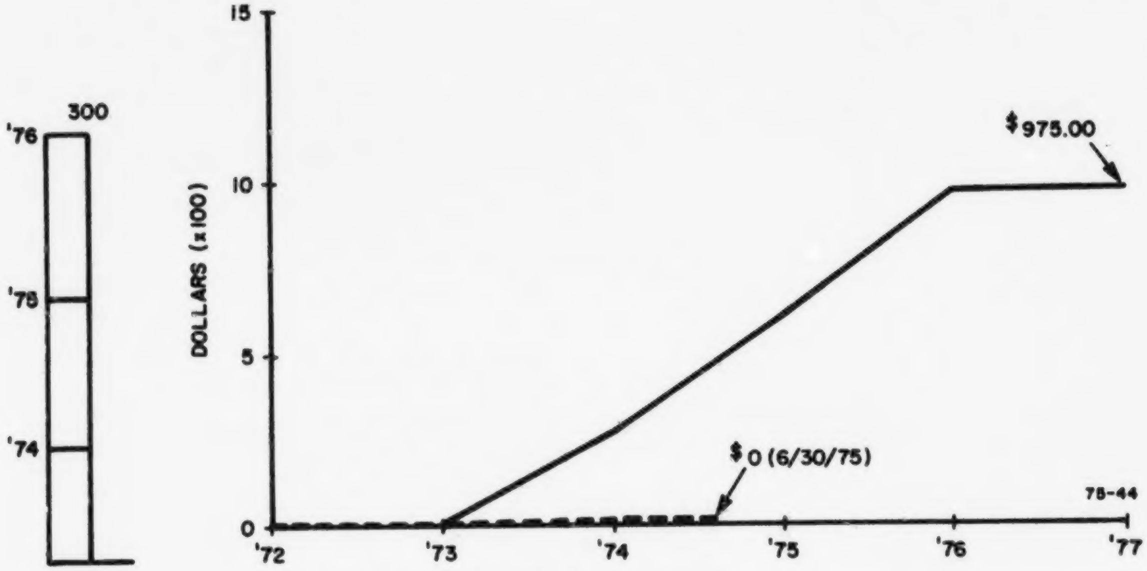


Figure 9.30 Stripcropping

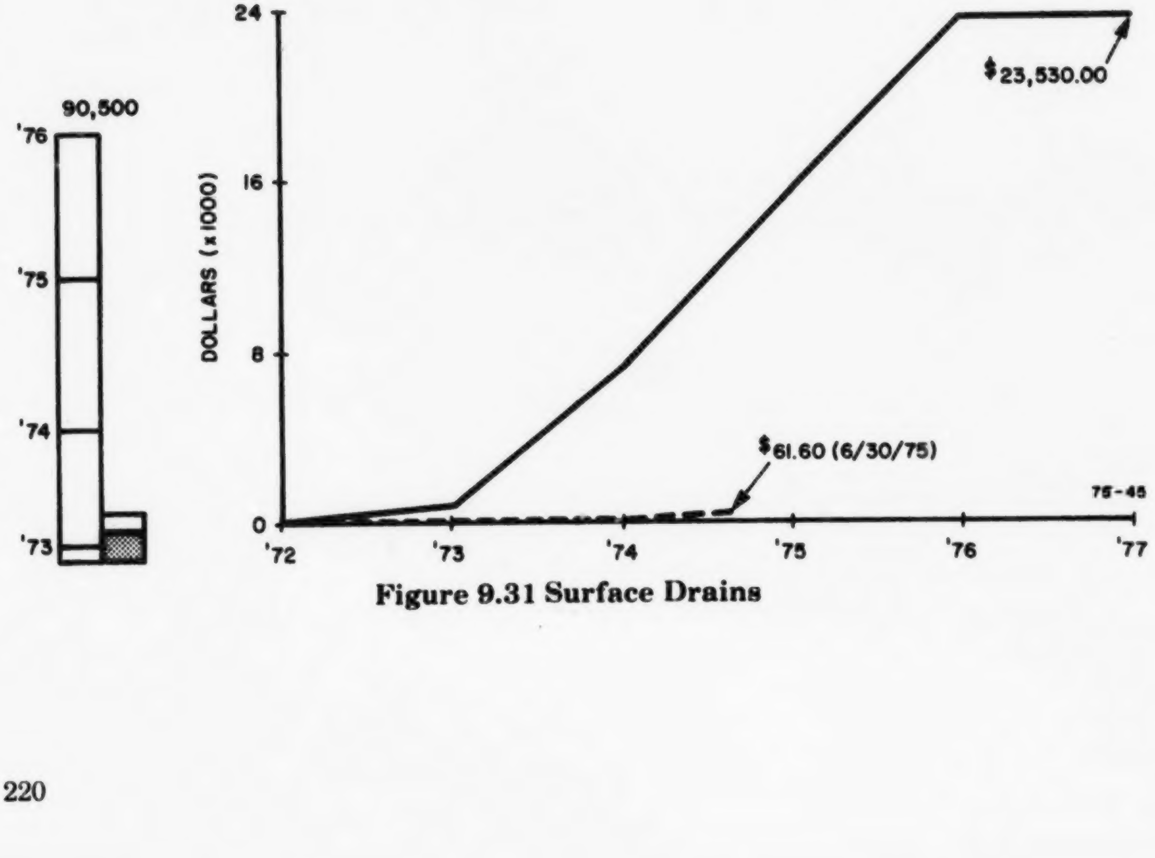


Figure 9.31 Surface Drains

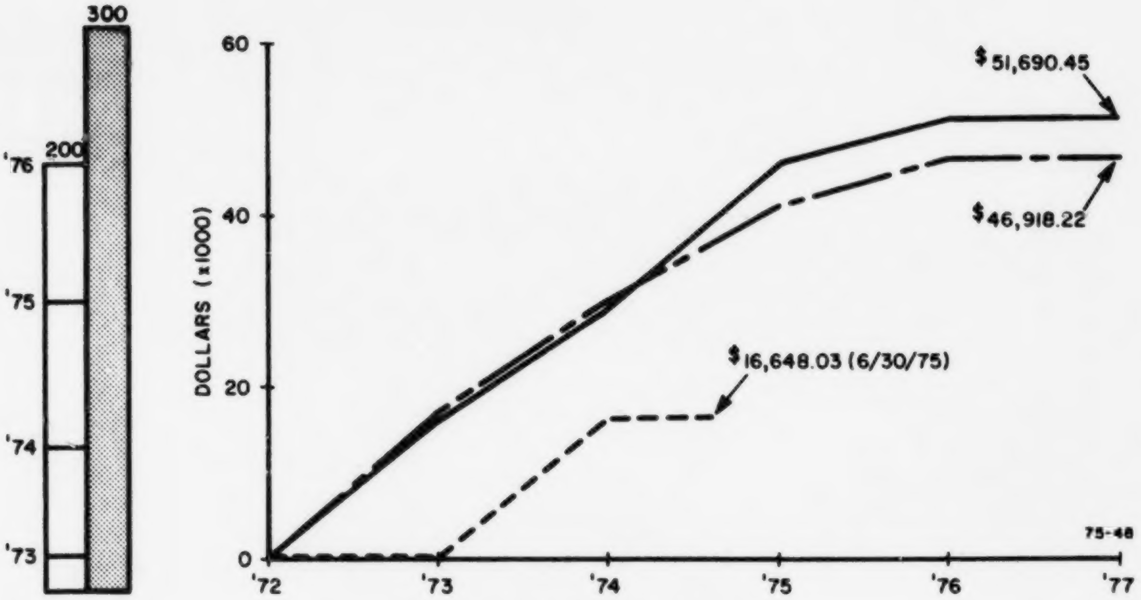


Figure 9.32 Tile Drains

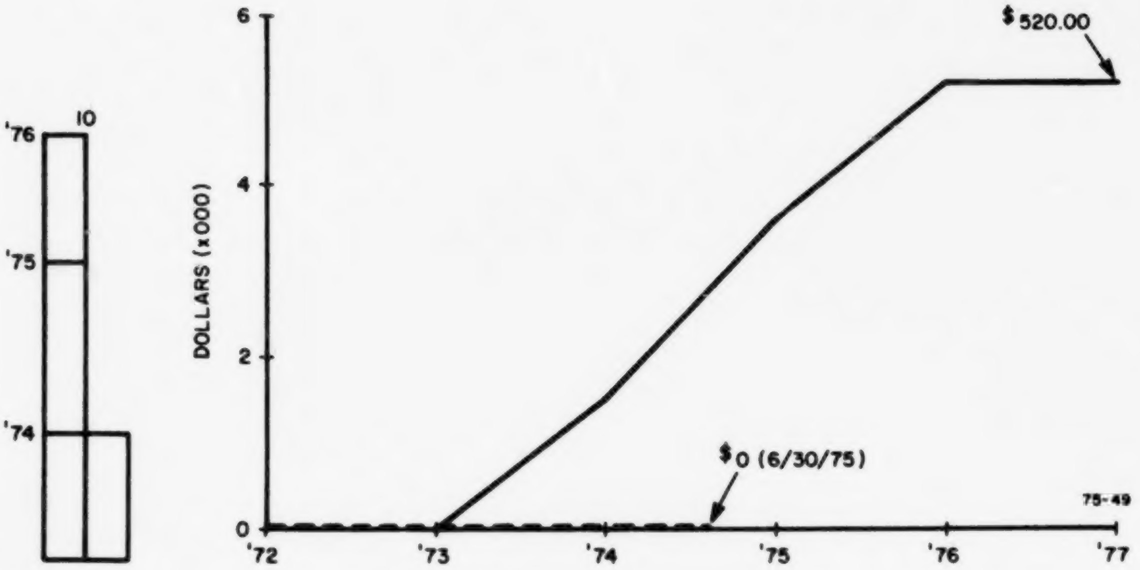


Figure 9.33 Tree Planting

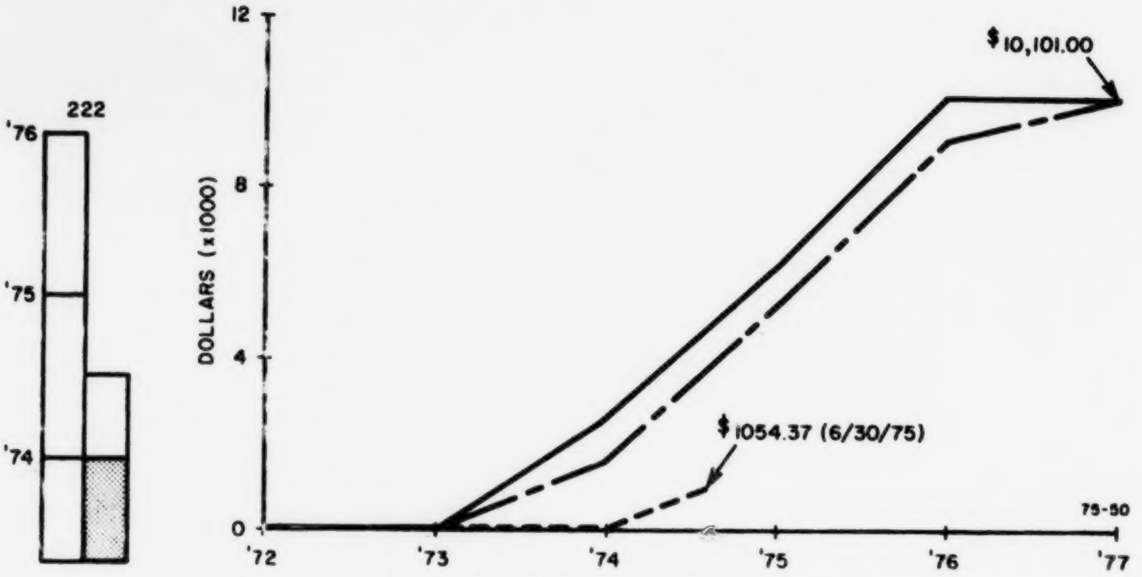


Figure 9.34 Wildlife Habitat Management

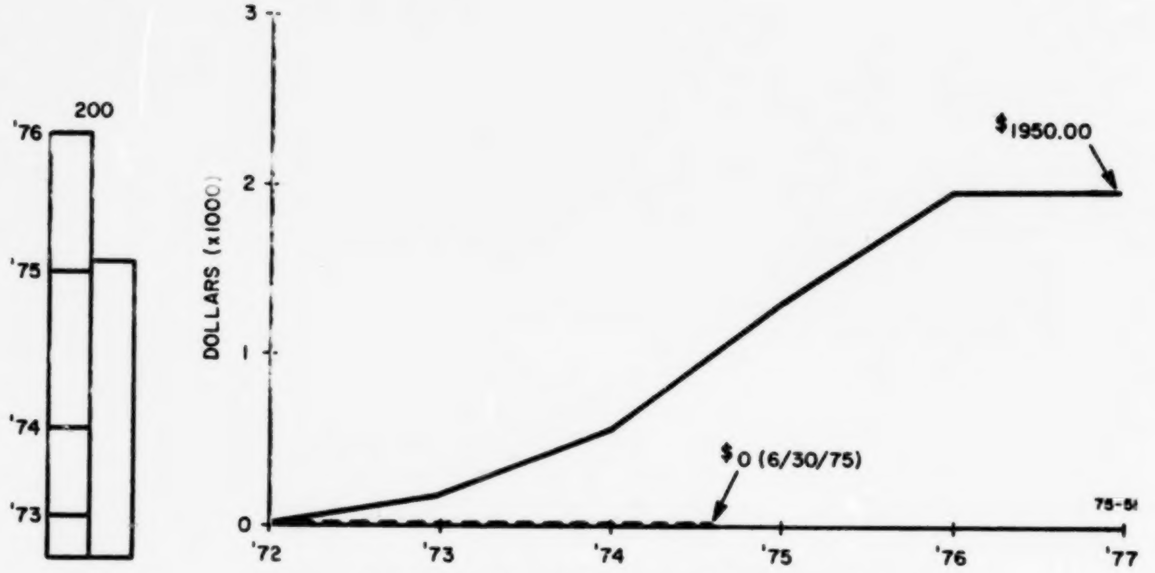


Figure 9.35 Woodland Improved Harvesting

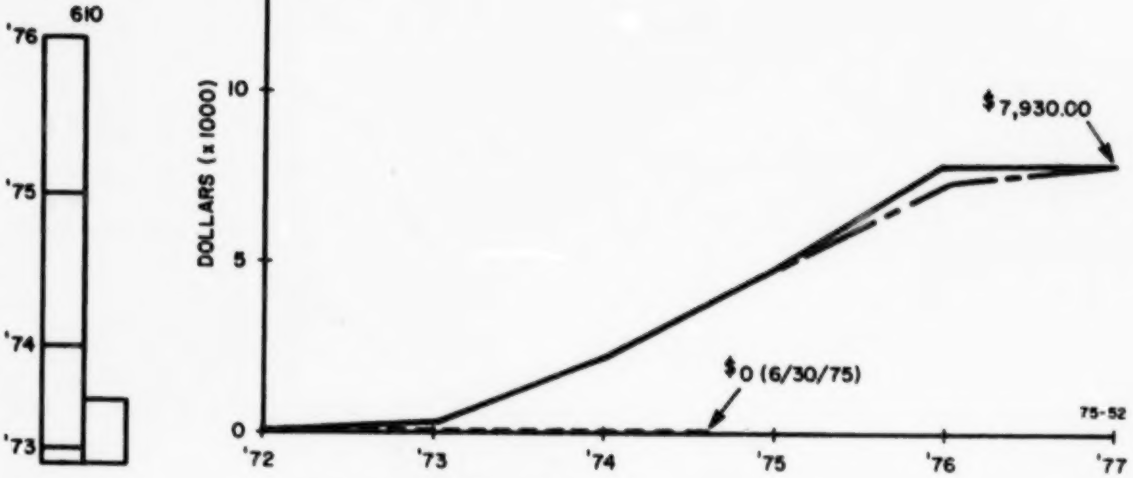


Figure 9.36 Woodland Improvement

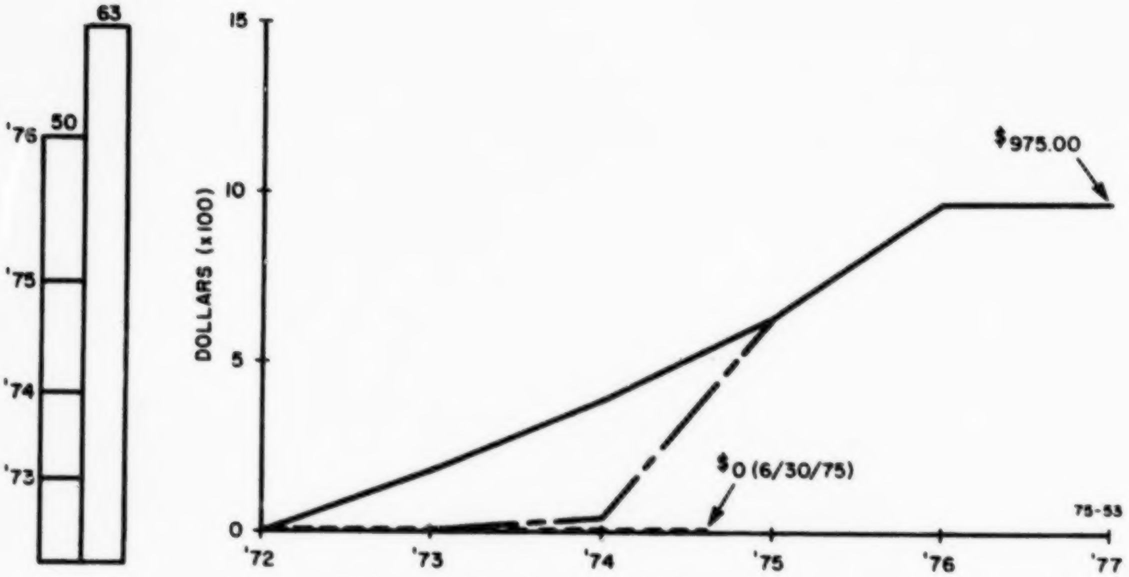


Figure 9.37 Woodland Pruning

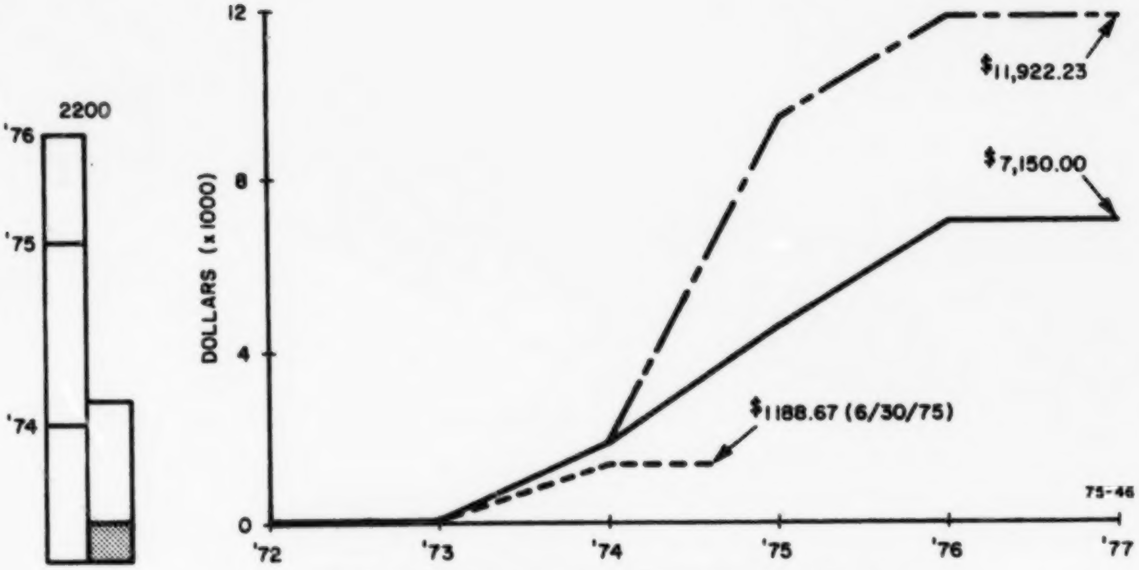


Figure 9.38 Terraces, Parallel and Gradient

# Appendix A
# Black Creek Maintenance Report

By
C. F. Poland
J. W. Dennison

The following is a report of the general condition of the Black Creek main channel as of June 30, 1975. The first portion of this report will deal with the project before the heavy rains of May, 1975; the conclusion will emphasize the effect of the abnormmal rainfall.

Generally speaking the main channel is in good condition, free of excessive deposition, brush, and inferior debris.

Minor sloughing is occurring at the low flow elevations but is not expected to be of major consequence.

Bank seedings in most areas are good to excellent, although some spot seeding would be beneficial.

Bank stabilization such as rip-rap stone and the low flow erosion barriers (stone) are in place and functioning as expected.

Fabricated erosion control structures and surface water inlet pipes in general are doing the job. Excessive earth settlement over or near these structures are annoying but correctible.

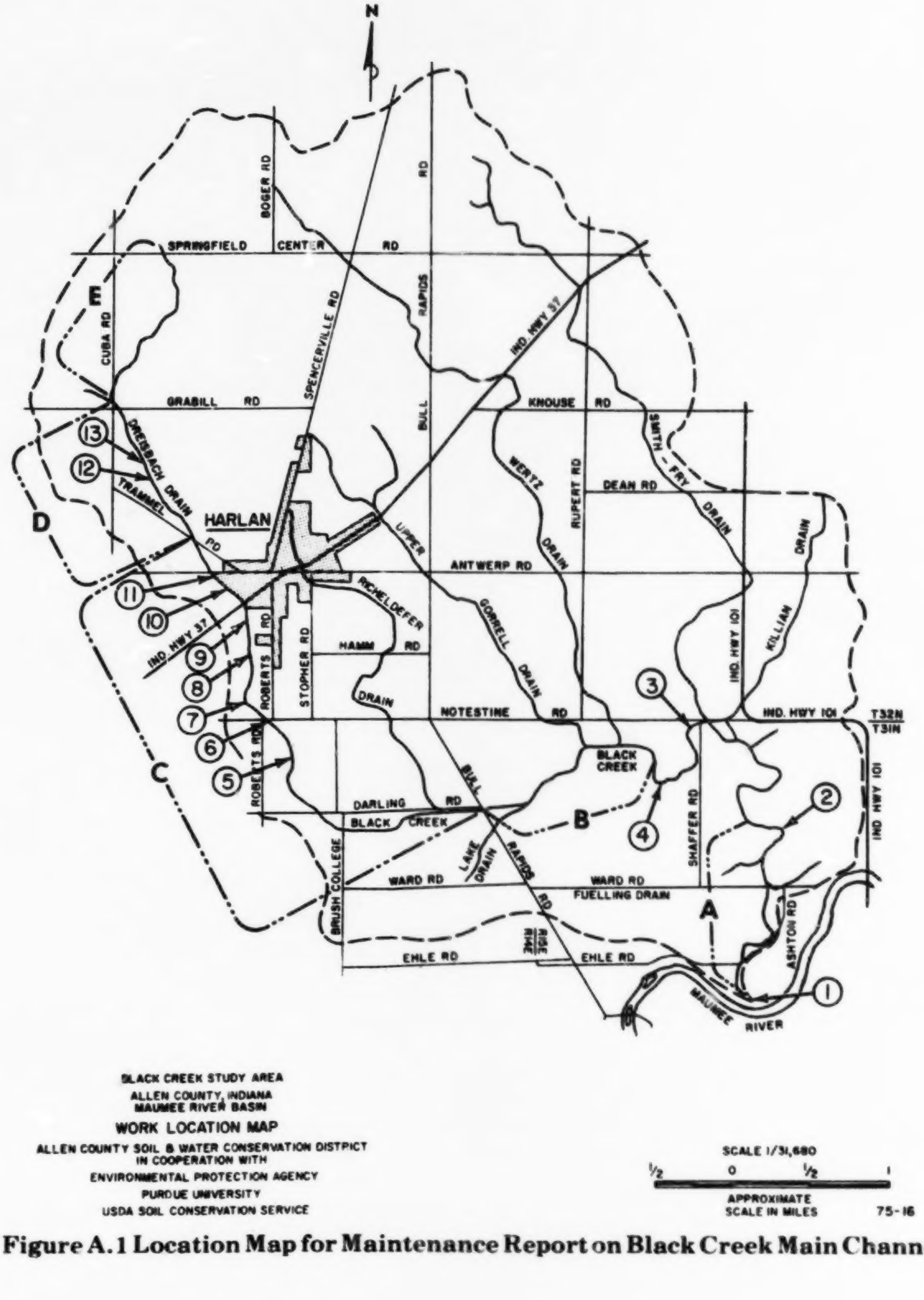
The "in-channel" rock drops are serving their purpose with little or no displacement of rock.

Notable channel degradation is occurring in the upper reach of Black Creek, known as Dreisbach Drain.

In the latter part of May, exceedingly heavy rainfall occurred in the watershed. Full bank flow was observed in the mid-reaches, out of bank and flooding in the lower rreaches. High velocities aggrevated the upper reach. Reassessment of maintenance was inevitable. Immediate and later observations revealed mass movements of soil adjacent and behind channel banks. Surface water inlet pipes and erosion control structures were taxed to capacity. In a few areas, over-topping occurred with one complete failure observed.

Where uncontrolled and concentrated runoff occurred, silt bars again appeared in the channel bottom. Presently, these are not of serious nature, but are in the process of causing low-flow meander.

Surface water entering the channel at the rock stabilization areas caused rock displacement creating need for immediate repair. The most significant area of concern is the Dreisbach Drain where serious channel degradation is occurring and bank conformation is being lost. Structural erosion control is also being threatened. This particular reach has been of primary concern due to the channel gradient, and the abnormal rain fall of May, 1975, has certainly contributed to this depreciation.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SPRINGFIELD CENTER RD
BOGER RD
BULL RAPIDS RD
SPENCERVILLE RD
IND. HWY 37
CUBA RD
E
GRABILL RD
KNOUSE RD
DREISBACH DRAIN
TRAMMEL RD
SMITH - FRY DRAIN
WERTZ DRAIN
RUPERT RD
DEAN RD
HARLAN
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UPPER GORRELL DRAIN
ANTWERP RD
RICHELDEFER DRAIN
KILLIAN DRAIN
IND. HWY 101
ROBERTS RD
STOPHER RD
HAMM RD
NOTESTINE RD
T32N
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BLACK CREEK
C
DARLING RD
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B
SHAFFER RD
BRUSH COLLEGE
LAKE DRAIN
WARD RD
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BLACK CREEK STUDY AREA
ALLEN COUNTY, INDIANA
MAUMEE RIVER BASIN
WORK LOCATION MAP
ALLEN COUNTY SOIL & WATER CONSERVATION DISTRICT
IN COOPERATION WITH
ENVIRONMENTAL PROTECTION AGENCY
PURDUE UNIVERSITY
USDA SOIL CONSERVATION SERVICE
SCALE 1/31,680
½ 0 ½ 1
APPROXIMATE SCALE IN MILES
75-16

Figure A.1 Location Map for Maintenance Report on Black Creek Main Channel.

Figure A-1 will provide location of specific areas of concern and general comments.

(1) Unstable right bank — caused by storm May 20, 1975, when there was high rate of flow from Black Creek and Maumee River was at low level.

(2) Rock in rock chute was moved by large rate of flow during May, 1975, storm. Rock was moved at the entrance of the chute and again at the lower end at the entrance to Black Creek.

(3) Rock rip-rap was installed on left bank for a total of 300 feet. Unstable soil below channel let the rock slip down and into the channel creating a partial block in the channel. The blockage was removed in the spring of 1975. Rock was placed back on approximately 3:1 side slopes. The weight of rock caused some slippage again, but at this time the left bank seems to be stable and the channel has enough capacity. It has been determined that nothing should be done to the channel at this time.

(4) Major silt bar in channel caused by erosion from cropland during May, 1975, storm.

(5) Excessive scouring along the channel banks where it was realigned.

(6) Rip-rap on left bank was moved from surface water coming in from a drainage area on the left side of the channel.

(7) Minor undercutting of erosion barrier.

(8) Channel bank slippage (right bank) occuring in deep cut area. The soils are a mixture of sandy and silts.

(9) Near this area along left bank two surface pipes are needed to take care of two places where surface water is causing serious bank erosion.

(10) Channel bank slippage along right bank because of seepage of water in sand lenses.

(11) Rip-rap was moved during May, 1975, storm from overbank flow from left bank. Rock should be placed back in original position.

(12) Erosion control structure on right bank has had movement of soil around the structure which needs some repair.

(13) Some degradation has occurred in the bottom of the channel because of steep gradient. This should be kept under close observation, because if it gets worse, side slopes could be undermined.

(a) Lower reach of Black Creek designated as "A" is in excellent condition and all disturbed areas have excellent vegetation. Along this portion of the creek, excellent field borders have been established between cropland and creek bank. The field borders caught and held considerable amount of silt from cropland during the May, 1975, storm.

(b) Reach "B" has field borders between creek side slopes and cropland. They are in excellent condition. Streambanks have excellent new grass cover. There are a few areas where bank slippage is occurring.

(c) Reach "C" has field borders in good conditions. They held soil in place during high flow from May, 1975, storm. The rock drop structure at the entrance of Richelderfer Drain to Black Creek is in excellent condition. There have been major volumes of flow past the structure since it was installed. There has been no movement of rock during the high flows. Silt has filled voids and there is almost complete cover of grass in the structure.

Streambank training (rock) of Black Creek channel. Upstream and downstream side of Notestine Road is in good condition. There is some evidence of rock undercutting as described earlier, however not serious at this time.

Rock drop structure at state Road 37 is in excellent condition. There was no movement of rock during May, 1975, storm.

Rock drop structure at Antwerp Road is in excellent condition. There was some movement of rock on left bank from overland flow into the channel as described in 11 above.

(d) Reach "D" vegetation along both side slopes and field borders is in excellent condition. Landowners are doing a good job of maintaining vegetation.

(e) Reach "E" sod waterway was constructed August, 1973. It is in good to excellent condition. Landowners have abused the vegetation at three locations. Soil Conservation Service personnel asked the landowners to remove livestock that was damaging the waterway and they were cooperative. The waterway had since been fenced, therefore in general landowners are now controlling the grazing, therefore maintaining good vegetation in most areas.

(f) Reach "F" upper portion is a sod waterway and lower portion reconstructed open ditch. The waterway was constructed late 1974, therefore a fair stand of sod got established. There is a fair stand of grass at the present time which will be good by next year. There was overtoping of storm water at Spencerville Road causing rip-rap rock to be moved. The rock was placed in original position and grouted with concrete. A direct opening into the tile with beehive grate to protect the opening was built so low flow could get to the drainage tile on each side of the waterway, therefore keeping the waterway dry during low flows.

The major portion of the open ditch has streambank lining (rock) to maintain stability of side slope. The rock did not move during the May, 1975, storm and is doing an excellent job of maintaining good side slopes protection.

(g) Reach "G" sod waterway was built August, 1975. The waterway has had heavy flow in it several times since it has been seeded. There is some grass in the bottom and excellent cover of grass on each side of the waterway. There was very little movement of soil in the bottom of the waterway. The waterway at the present time is in good condition, and should have heavy grass cover throughout by next year.

In summary, with consideration for the adverse conditions of 1975 and the infancy of the project, the main is in good condition. However maintenance is ever-present and demanding.

Participation for this report consisted of personnel in charge of maintenance, Allen County Surveyor's office and personnel of the Soil Conservation Service technical staff.